Engineering Library

SHIPPING, ENGINEERING AND MACHINERY EXHIBITION.

The Engineer

ESTABLISHED 1856. REGISTERED AS A NEWSPAPER.

VOL. CLX.—No. 4157] 28, ESSEX ST., LONDON, W.C. 2. [SEPTEMBER 13, 1935

SEP 1935

FOR CHILLED ROLLS

specify

NI-HARD

Ni-Hard is a chilled cast iron alloyed with nickel and chromium to improve hardness, wear-resistance and strength. The effect of the alloy content is to strengthen the matrix of the iron, and to raise its hardness to a figure similar to that of the carbides which are embedded in it. The surface hardness of a chilled roll is thereby raised from the usual figure of about 65, to 90 or even 95 Shore.

The strengthening of the matrix ensures long life and freedom from "spalling," and the improved wearing quality results in the maintenance of the high finish which can be developed on these rolls as a result of their fine grain.

On account of their quality Ni-hard rolls are successfully replacing more expensive steel rolls for cold working and finishing both ferrous and non-ferrous metals. Softer grades, usually known as modified Ni-Hard are used for hot breaking down and hot working generally.

For further particulars return this coupon

THE BUREAU OF INFORMATION ON NICKEL
THE MOND NICKEL COMPANY, LTD.
THAMES HOUSE, MILLBANK, LONDON, S.W.1.

Please send, free of charge, further information on Ni-Hard Rolls.

Name.....

Address.....

.....

To The Bureau of Information on Nickel,
THE MOND NICKEL COMPANY LTD.,
Thames House, Millbank, London, S.W.1.

35 B 8

W. MARTIN WINN LTD

Manufacturers of—

STRENGTH

BRIGHT STEEL

ACCURACY

SPECIALITY:
BOLTS, NUTS, RIVETS, &c.
for Marine Engineering

IMMEDIATE DELIVERIES of
BOLTS, NUTS, &c., to latest Admiralty Specifications

Head Offices and Works:—
Station Works, DARLASTON, South Staffs, Eng.

Telephone: Darlaston 72 (3 lines) *Telegrams: "Accuracy," Darlaston.* *Codes: A.B.C. 5th Edition*

ON ADMIRALTY AND WAR OFFICE LISTS.

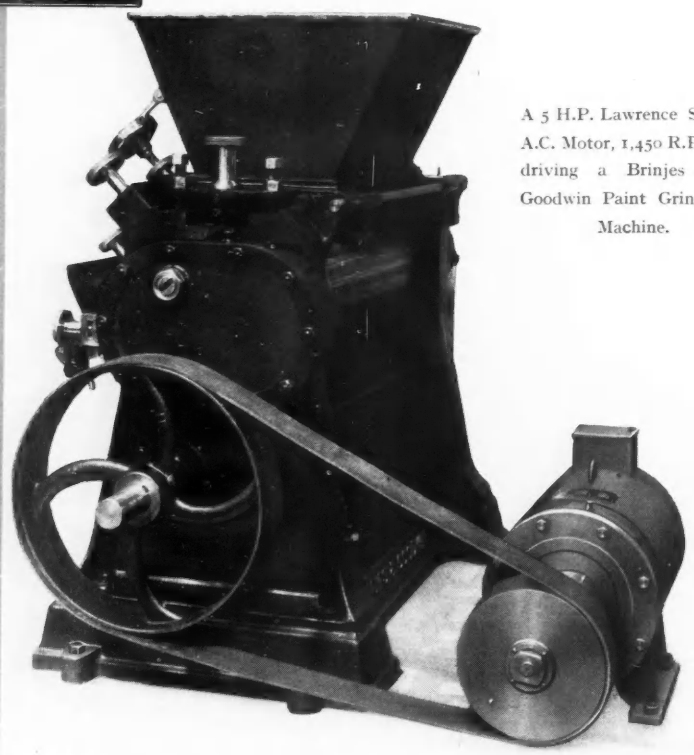
BRIGHT BOLTS & NUTS

WE ARE EXHIBITING AT
SHIPPING ENGINEERING AND MACHINERY EXHIBITION
SEPT 12 TO 28 1935
OLYMPIA

Make a point of visiting our

STAND No. 2, Row J

All Units in operation under load



A 5 H.P. Lawrence Scott A.C. Motor, 1,450 R.P.M., driving a Brinjes and Goodwin Paint Grinding Machine.

WEARN'S AUTOFLEX PULLEYS

- EMBODY ALL THE ADVANTAGES OF WEARN'S DRIVE
- IDEAL FOR INDIVIDUAL OR GROUP DRIVES
- CHEAP HIGH SPEED A.C. or D.C. MOTORS CAN BE USED,
- AND MINIMUM CENTRE DRIVING
- WITH SINGLE FLAT BELT AUTOMATICALLY TENSIONED
- ENSURING ECONOMY IN POWER CONSUMPTION
- BESIDES OFFERING 4 : 1 SPEED REDUCTION
- AND LOW MAINTENANCE COSTS
- SOLVE YOUR TRANSMISSION PROBLEMS IN TERMS OF WEARN'S UNITS

WEARN'S AUTOFLEX DRIVES LTD. 2, SLOANE TERRACE, SLOANE SQ., S.W.1 TELEPHONE: SLOANE 2154

A Seven-Day Journal

The Laurentic.

IT will be recalled that on August 18th the Cunard-White Star liner "Laurentic" was involved in a collision off Liverpool with the freight liner "Napier Star." The accident occurred in a fog and the "Laurentic" suffered so much damage that she had to cancel the pleasure cruise to the Baltic ports on which she had started a few hours before, and return to Liverpool. Her bows were badly crushed and six seamen who were in the forecastle at the time of the accident were killed. On re-arrival in the Mersey the liner was at once handed over to Harland and Wolff, Ltd., for urgent repair, on the agreement that she should be ready to resume her duties on Friday, September 6th. Between two hundred and three hundred men were promptly put to the work and, working day and night, completed the repairs by September 4th. This is considered to be one of the smartest bits of repair work carried out for several years. We are informed that the vessel shows no trace whatever of the damage she suffered. She sailed on Friday last for Dublin, where she picked up Lourdes pilgrims. Two more trips carrying pilgrims to Le Verdon are in her programme.

New Keswick Road.

IT appears that some difficulty and controversy has arisen over the proposed new road at Keswick. Two different routes have been advanced. The Cumberland County Council proposes to by-pass Keswick on the lake side of the town, whilst the Keswick Urban District Council proposes to build a road running from the Market Square, Keswick, to a minor road, which would be widened to 40ft. and carried into the Borrowdale-road. Both Councils applied for a grant from the Road Fund! Needless to say, the Ministry of Transport intimated to the Councils that it could not give aid to both schemes. It urged the local authorities to put their heads together and decide which scheme would be the better. In consequence the Urban Council has appointed a sub-committee to discuss the subject with the County Council. As other roads have been suggested it is possible that neither of the present alternatives will be adopted. In any case Keswick is opposed to the proposed county road, which, by providing a by-pass to western Lakeland and to Borrowdale, would leave the town high and dry as far as tourist traffic was concerned. A plebiscite taken by Keswick when the road was first advanced by Professor Abercrombie in his regional town planning survey of the district was overwhelmingly against it.

Employment Figures for August.

THE official returns of employment were issued on Monday, September 9th. They give the number of insured workers employed on August 26th last as 43,000 higher than in the previous month, and 244,000 higher than a year ago. The number unemployed has fallen by 24,977 compared with July 22nd, and by 188,614 compared with August, 1934, this making a total of 10,424,000 insured persons in employment and 1,947,964 persons unemployed. The previous highest figures were reached in July last, and they have easily been passed, the present figures being the highest for fourteen years in employment and the lowest for five years in unemployment. The returns have been influenced by the annual registration of juveniles leaving school at this period, which caused an increase of nearly 22,000 unemployed juveniles on the books. Among adults the improvement has been continuous since January last, 350,000 persons having found employment since then, 47,000 during the last month. The improvements were manifested in the reduction of unemployed by the following figures in different industries:—Coal mining, 50,944; woollen and worsted, 24,654; cotton, 22,517; boot and shoe manufacture, 14,019; iron and steel manufacture, 11,533; engineering, 16,464; building, 11,083; shipbuilding, 8494, and motor industry and aircraft, 6092. Since 1921, when statistics were first made available, the amount of reduction between the January and the August figures has only been exceeded twice—in 1922 and in 1933.

The River Severn Road Bridge.

AT the request of the Roads Improvements Association, Sir Alexander Gibb and Partners have investigated the possibilities of a road bridge over the river Severn. The national importance of improving the communications between South Wales and South-West England has, they say, long been obvious. To obtain the maximum value from the bridge the site should be at the lowest practicable point on the estuary. The site recommended is therefore at English Stones, a few hundred yards below the line of the Severn Tunnel. It is estimated that a bridge here would cost about £1,554,000 and would take about four years to complete. As it would constitute a national highway, there is justification for the Government to grant the maximum assistance, 85 per cent. of the cost, from Treasury funds. The remainder of the cost would be met, it is estimated, by a toll on vehicles using the bridge during a period of ten to fifteen years. The navigational requirements of the Severn estuary necessitate a high-level bridge. Owing to the bare rock bed of the estuary, no difficulty would arise in the construction of such a structure, nor would it constitute a navigational difficulty at this point, as the shipping channel known as "The Shoots" has only a width of 1500ft., which would be left clear of obstruction by the bridge. The remainder of the bridge would be constructed over rock exposed at low tide over most of its area. The cost of roads to link up the bridge with the existing road system would not be great, not more than seven miles being required. The design of the bridge includes a 30ft. roadway, two 5ft. footpaths and 20ft. approach roads. To meet the upkeep costs, interest, &c., £24,000 a year would be required which would be provided by a toll of 1s. per vehicle on 1320 vehicles per day. The estimated traffic which would be attracted to the new bridge is 2500 vehicles per day. A second possible site exists at Chepstow. No structural objections to it exist, but the presence of the town of Chepstow would necessitate the construction of a by-pass approach road to the bridge, and this road would have to cross the river Wye. Assuming that a bridge over the Wye need have no greater headroom than is at present provided by the existing railway bridge, the cost of the whole Chepstow scheme would be £1,564,000. Should additional headroom be required the cost would be increased by £150,000; that, however, is considered unlikely.

Loans for Public Works.

AN interesting and useful publication has just been issued for the first time by the Ministry of Health. In it are compiled the total of loans for capital works exclusive of housing schemes sanctioned by the Minister. The publication is to be produced monthly. The first return gives the total of sanctions to Authorities in England and Wales for each month of the financial year 1934–35, and for the first five months of the present financial year. For 1934–35 the total amounts to £26,026,397. For 1935–36 the five months passed cover a total of £14,936,354, this figure being made up of £2,403,388 advanced on trading services, while £12,532,966 was advanced on non-reproductive services. The highest total reached during the last five years was that of 1930–31, the annual returns being: 1929–30, £36,358,352; 1930–31, £47,365,434; 1931–32, £34,375,486; 1932–33, £19,980,902; 1933–34, £20,344,465. The last two figures show an upward tendency, which continues in the £14,936,354 for the first five months of this year when this figure is compared with £10,752,392 for 1934–35 over the same period. The major outlays by local authorities have been on roads, bridges, and street improvements in towns, on sewerage and sewage works, schools, aerodromes, waterworks, and open-air baths. About £2,000,000 has been sanctioned for sewerage and sewage works during the past three months.

Cargo Ships in Winter.

THE Board of Trade has sent out a letter which calls the attention of owners of cargo ships to the necessity for special care being taken of steering gear, auxiliary gear, hatch covers, &c., and of the annual load line survey regulations when winter voyages in the North Atlantic or elsewhere are in contemplation. The letter is a sequel to the findings of the formal investigations into the loss of the "Ushworth," "Blairgowrie," and "Millpool" last winter. It notes that committees are now investigating the questions raised as to the steering gear condition and as to manning, and that arrangements for survey are being discussed with the classification societies. As reports on these matters are unlikely to be produced in time to be acted on during the next winter season, the Board of Trade is passing on the following recommendations of the committees to the owners for consideration. They are that thorough overhauls of steering gear should be undertaken before the start of winter voyages. Some shock absorbing arrangement should be provided for auxiliary steering gear, which should be stowed in an accessible position in the ship. Hatch covers, tarpaulins, coamings, with their lashings, &c., should be examined carefully and extra lashings provided even when not called for by the Load Line Rules, 1932. The Annual Load Line Survey should be expedited so as to be completed by November 1st next for all ships irrespective of the date of the 1934 survey.

The Tramp Shipping Subsidy.

ON Monday last, September 9th, the Board of Trade issued an announcement recalling the recommendation made to it by the Tramp Shipping Subsidy Committee that in respect of the first two quarters of the subsidy year the amounts payable to shipowners should be adjusted so as not to exceed the amounts which they would have received had only 90 per cent. of their eligible tonnage been trading. This recommendation was made in order that the tramp shipping subsidy should not offer an incentive to owners to trade more tonnage than the freight market might warrant. Accordingly, the payments shortly to be made in respect of the second quarter of the subsidy year will be adjusted by the necessary figure, for which purpose the amount of tonnage laid up by each owner during the first six months of the year will be taken into consideration. The Committee now recommends that the Board should maintain the figure of 90 per cent. in operation for the third quarter of the year. In accepting the figure the Board has decided to make no adjustments on this account until the end of the subsidy year, when the amount of tonnage laid up during the whole twelve months will be considered in adjusting the payments to be made. Whether the figure of 90 per cent. should be maintained for the fourth quarter of the year or not is now under consideration by the Committee, and a further announcement will be made on the subject in due course.

Electricity in Palestine.

ADDRESSING the shareholders of the Palestine Electric Corporation, Ltd., on Thursday, September 5th, the chairman, Lord Reading, gave some interesting facts about the developments of electricity supply in the Holy Land. The present total generating capacity of all the power stations of the Corporation is 41,275 kW, but further extensions are required to meet the growing demand. Hence another complete unit with a 12,000 kW alternator is on order for the new Haifa power-house. Furthermore, material is on order for a second 66,000-volt transmission line from the first Jordan power-house to Tel-Aviv, as the existing line will soon become inadequate for the increasing load. Surveys are being carried out with a view to further hydro-electric developments between Lake Huleh, in the upper reaches of the river Jordan, and Lake Tiberias. Maximum and minimum levels of the lake have been fixed by the Government and accepted by the Corporation, which has undertaken to bear the cost of protective works in respect of the shores of the lake, and of anti-malarial measures in that region. During the last financial year the Corporation laid 31 kiloms. of high-tension underground cable and 152 kiloms. of overhead high-tension, and 160 kiloms of overhead low-tension transmission lines. At the end of last year it owned 787 kiloms. of high-tension and 606 kiloms of low-tension lines. During the year one hundred and thirty-nine new transformers with a total capacity of 13,630 kVA were installed on consumers' premises. The Haifa power-house, with a capacity of 18,000 kW, was completed and brought into full operation some time ago.

The King's Cup Air Race.

ON Saturday last, September 7th, the King's Cup Air Race was won by Flight-Lieutenant T. Rose at a speed given as 176·28 m.p.h. His machine, which was entered by Lady Wakefield, was a Miles "Falcon," low-wing, cabin monoplane, fitted with a 200 h.p. "Gipsy Six" engine. Flying Officer H. R. A. Edwards was second in Mr. R. Cornell's Miles "Hawk" Trainer, and Lieutenant O. Cathcart-Jones was third in another "Hawk" Trainer, entered by Major G. W. G. Allen. The Siddeley Trophy was won at an average speed of 170·08 m.p.h. by Mr. C. E. Gardner, of Redhill Flying Club, in a Percival "Gull" Six. He was seventh in the race. The fastest speed recorded in the race was 208·91 m.p.h., averaged by the Duke of Kent's "Mew Gull" machine, flown by Mr. E. W. Percival. This is the fastest speed ever recorded in the race. In four successive laps of the seven a speed of 211 m.p.h. was maintained. Mr. Percival, in spite of this speed, lost the race on handicap. Only one competitor flew at less than 130 m.p.h., which was the minimum speed set for the race. Among the first ten machines were seven from the high-powered section, all using "Gipsy Six" engines, rated at 200 h.p. All the other competitors, except one, used "Gipsy Major" engines of 130 h.p.

The Passing of Two Liners.

THE "Olympic" is to be broken up at Jarrow-on-Tyne. She has been purchased from the Cunard-White Star Line for £100,000 by Sir John Jarvis for the express purpose of finding work for Tynesiders. At Jarrow she will pass into the hands of a new ship-breaking company, which, it is understood, is to be worked on the co-operative plan. Sir John will make no financial profit out of the transaction. The "Olympic" is a liner of nearly 46,500 tons gross, and has crossed the Atlantic five hundred times in her twenty-four years of existence. She was built and engined by Harland and Wolff in 1911, and is over 852ft. long. She was fitted with triple-expansion engines, exhausting into low-pressure turbines, giving a total s.h.p. of 18,000. Owing to her great draught even in a light condition, dredging of the Tyne will be necessary to allow her to get up to the yard. Another liner well known for many years by travellers to the Far East is also destined immediately for the breaker's yard. She is the P. and O. ship "Mantua," of 11,000 tons, and is now making her last voyage to Japan, where she will be broken up. Her place in the service is to be taken by the "Strathmore," now nearing completion. The "Mantua" was built and engined by Cairds, of Greenock, in 1909. She has quadruple-expansion engines driving twin screws, giving a speed of 18½ knots. Her gross tonnage is 10,900 and her length 540ft.

Electric Driving.

No. IV.

(*Continued from page 236, September 6th.*)

SCHEMES have been devised to obtain speed variation on slip-ring induction motors by injecting an E.M.F. of the correct frequency into the rotor circuit. With a definite supply voltage and frequency the rotating field in an induction motor is of constant value, and has a constant synchronous speed, dependent upon the number of poles. The rotor E.M.F. depends upon the difference between this speed and that of the rotor. If no E.M.F. be injected the machine runs with a small percentage slip, which corresponds to the rotor resistance drop. To reduce the speed below synchronism or increase it above synchronism, it is necessary to inject an E.M.F. in phase with the induced E.M.F. and of the correct slip frequency. The effect of this on the motor speed is shown in Fig. 32. In the case of small machines, a speed range

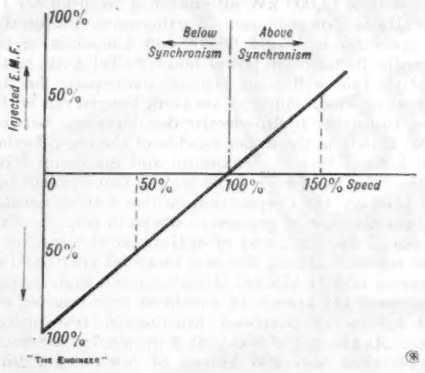


FIG. 32—RELATION BETWEEN SPEED AND INJECTED E.M.F.

of 3 to 1 is often required, and the speed will be varied between 150 and 50 per cent. by injecting an E.M.F. of ± 50 per cent. of the full standstill rotor voltage for the extreme speeds and less for the intermediate speeds. This percentage variation from synchronism is known as the regulation, and for large motors, such as 1000 to 2000 h.p. rolling mill machines, a regulation of 20 to 30 per cent. is more usual.

When the speed is reduced by an external rotor resistance and the input remains constant, the output is decreased in proportion to the speed, the difference, known as the slip power, being dissipated in the resistance. While the output is also reduced if a regulating machine is employed, the slip power is not wasted, but is passed on to that machine which will deliver back either mechanical or electrical power. If the motor is required to work above synchronism the regulating machine must supply the motor with the

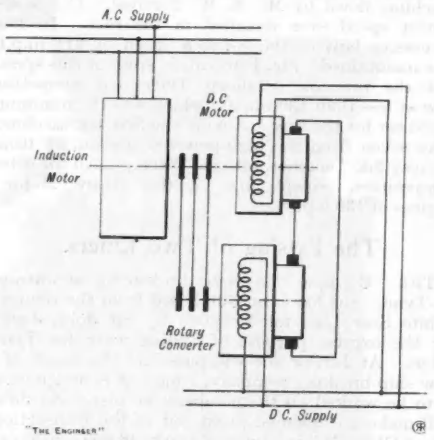


FIG. 33—KRAMER EQUIPMENT

power corresponding to the negative slip. The size of the regulating machine therefore depends on the percentage regulation, and the speed range is much larger for the same size of machine if the main motor runs above synchronism as well as below it.

In the Kramer scheme—Fig. 33—the slip rings of the induction motor feed a rotary converter at low frequency, and the slip power is converted to D.C. The converter supplies a D.C. motor, which either drives an A.C. generator and returns electrical power to the line, or is directly coupled to the main motor and returns mechanical power to the shaft. Speed changes are made by altering the field strength of the D.C. machine. Although the scheme has been employed to some extent it presents the disadvantage of necessitating the use of several machines, and as the motor only operates below synchronism, the maximum power of the regulating machine is nearly twice as great as that needed for a double-range set. On the other hand, the scheme has the advantage that all the machines are standard units.

In all other schemes to be considered here the induction motor slip rings are connected to the brushes of a commutator cascaded machine having an armature similar to that of a D.C. machine. The brushes are spaced 120 deg. apart, and if the armature is in a rotating field they have three-phase voltages between them. The various schemes differ from one another according to the way in which the revolving

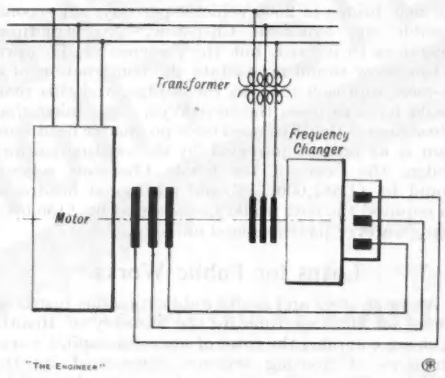


FIG. 34—FREQUENCY CHANGER EQUIPMENT

field is produced. It can be provided, for instance, by a three-phase stator winding, and the speed of the field will depend on the frequency of the voltage across it. A point to be noted about a commutator winding in a rotating field is that the frequency of the voltage between the brushes corresponds to the speed of the field, and is independent of the armature speed. Although the actual conductors between the brushes are changing continuously, the conductors between the brushes are in the same position at any instant, and the fact that the armature rotates does not affect the frequency. To vary the frequency it is necessary to vary the speed of the rotating field. The magnitude of the voltage depends on the magnitude of the field, as well as on the speed at which

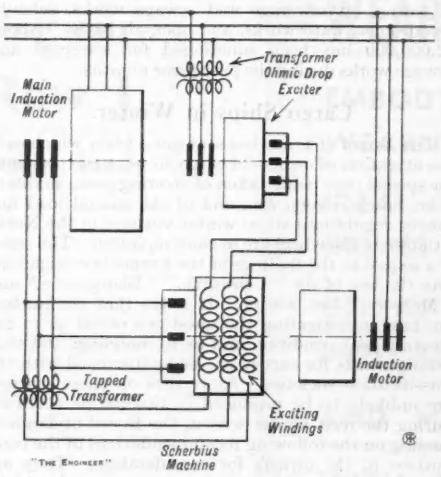


FIG. 35—SCHERBIUS EQUIPMENT

the conductors cut the flux, and these properties of a commutator machine make it possible to obtain an E.M.F. of variable frequency for regulating the speed of an induction motor by injecting the E.M.F. into the rotor circuit.

The injected E.M.F. must be of slip frequency; in other words, an E.M.F. with a frequency which corresponds to the difference between synchronous speed and the actual mechanical speed required. Hence, the rotating field of the commutator machine has to rotate with the speed corresponding to this frequency, and a method of obtaining this speed is to provide a three-phase exciting winding on the stator and to excite it at slip frequency. The field will then rotate at the corresponding speed and the armature voltage will have the same frequency. An example of this type of regulator is the Scherbius regulating machine, made by the G.E.C. of America. This is shunt excited from an auto-transformer with variable taps, connected to the main slip rings, and is thus shunted across the rotor.

Another type of regulating machine is a frequency changer—Fig. 34—in which the field is set up by currents at full supply frequency flowing in the rotor. In its simplest form the regulating machine is like a rotary converter without a stator winding, and the supply is led in through three or six slip rings connected to points on the armature winding. The machine is directly coupled to the main motor, which has the same number of poles so that its speed is less than the synchronous speed by an amount corresponding to the slip. The field set up by currents flowing from the slip rings at supply frequency rotates at synchronous speed relative to the rotor, and if the phase rotation is correct, the field rotates in space at slip speed. Thus, in a machine of this type fed from the slip rings and run at exactly the same speed as the induction motor, the field rotates

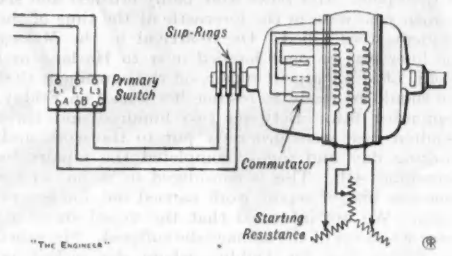


FIG. 36—NO LAG MOTOR

at slip speed and the voltage between the brushes is of slip frequency, so that it can be used for regulating the induction motor speed.

As in the case of a rotary converter the slip ring and commutator voltages have a fixed ratio, and to vary the voltage to obtain speed variation a tapped transformer between the supply and slip rings of the regulating machine can be used, when each tapping gives a definite speed. In the B.T.H. A.C. commutator motor described in the previous article and illustrated in Fig. 22 (*ante*), the two machines are combined in one, the difference being that instead of supplying the full frequency to an extra set of slip rings, the main field of the motor is used to induce the regulating voltage. It will be remembered, moreover, that the arrangement of the stator and rotor is opposite to that of an ordinary induction motor, the primary being on the rotor and the secondary on the stator.

In the Scherbius regulating machines the stator winding is fed from a tapped transformer shunted across the main motor rotor winding and each tapping causes the main motor to run at a different speed. But in its simplest form the regulating machine cannot produce a voltage which will raise the speed of the main motor above the synchronous value. Only sub-synchronous operation is possible which may or may not be satisfactory. Speeds above synchronism may, however, be secured by connecting a small frequency changer of the type described in series with the Scherbius machine, as shown in the

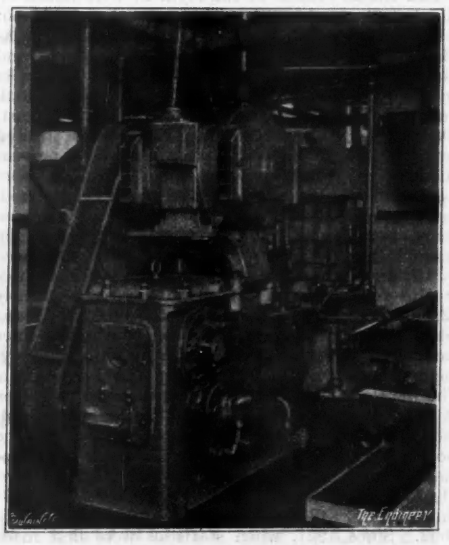


FIG. 37—DUAL FREQUENCY MOTOR DRIVE

diagram, Fig. 35. The function of this machine, known as an "ohmic drop" exciter, is to supply a constant voltage of slip frequency to provide some excitation for the regulating machine when it is operating near synchronism, and the induction motor slip ring voltage is practically nothing. With the aid of this small "ohmic drop" exciter the speed can be regulated above synchronism.

Since in cascaded sets the wattless component of the ampère turns can be supplied from the rotor, these sets can be used for power factor correction. This can easily be brought about by changing the phase of the flux in the commutator machine relative to the brushes, the simplest method of doing this being to move the brush gear bodily, since the phase of the E.M.F. depends on the brush position. In a B.T.H. Schrage commutator machine, as illustrated in Fig. 22

(*ante*), power factor correction may be obtained by a backward shift, the mean position of the two sets of brush gear being displaced from the neutral position. When commutating poles are used the brushes cannot be displaced and other means have to be employed. With a Scherbius regulating machine the phase of the flux is altered by suitably interconnecting the phases of the auto-transformer, which provides the exciting current.

These two types of machines can be used as phase advancers, which correct the power factor without giving speed regulation, and since the regulating machine no longer deals with power, it is considerably smaller than when it is used for speed regulation. A modification of the motor illustrated in Fig. 22 (*ante*) used in this way is the B.T.H. "no-lag" motor. Another very similar machine is the Kosfi motor made by the English Electric Company. The former is shown diagrammatically in Fig. 36. Like the speed regulating machine shown in Fig. 22 (*ante*), the "no lag" motor has its primary winding on the rotor and the secondary winding on the stator. The supply is fed into the rotor through slip rings and, in addition to the primary winding, the rotor carries a compensating winding in the same slots that carry the primary winding and is provided with a commutator and brushes connected in series with the stator winding. The constant commutator voltage is thus injected into the secondary circuits and produces currents which cause the primary current to alter in phase, thereby improving the motor power factor. By varying the brush position the phase of the commutator voltage can be altered to enable the amount of correction to be controlled. Motors designed for leading power factor give without any adjustment almost constant leading kVA at all loads from 125 per cent. full load down to no-load. "No lag" pensating windings is permissible. When fed with a tapped transformer the frequency changer type of regulating machine can also be provided with commutating poles, but since the machine has the same number of main poles as the induction motor to which it is coupled, the arrangement is usually more clumsy than a corresponding Scherbius machine which has fewer poles. With a variable-speed A.C. machine having two sets of brushes the position of the short-circuited coils changes as the brushes are moved and commutating poles cannot be employed. The machine must therefore be designed so that the voltage in the short-circuited coils is limited to that which can be dealt with without them. Among other things, this sets a limit to the size and speed of the machine, which is suitable for small and medium outputs. A rather wider range can be covered by using the separate frequency changer, but for really large outputs the Scherbius equipment is put forward by the B.T.H. Company.

The standardisation of frequency in this country has given rise to a demand for induction motors capable of operating at either of two frequencies—an existing frequency of 25 or 40 cycles and the standard frequency of 50 cycles. By using a motor of this kind on a non-standard system no inconvenience is caused when the change over to the standard frequency is made. One of the conditions to be met by a dual frequency motor is that when called upon to work with the standard frequency of 50 cycles per second its outputs and speed will not differ by an amount likely to trouble the user. Another requirement is that its efficiency, power factor, and torque must not be unduly impaired. Since for a given number of poles the speed varies directly as the supply frequency, it follows that to obtain constant speed with different frequencies the number of poles must be changed.

English Electric Company, and the B.T.H. Company.

Although special motors for variable speed, power factor correction, and motors suitable for use on supply systems on which the frequency is likely to be changed are in demand, the great majority of machines

FIG. 41—500 H.P. MOTOR DRIVING SHAFTING

installed in factories are standard squirrel-cage or slip-ring machines, which are, naturally, cheaper than the more complicated types. Innumerable articles have been written on the conversion of factories of many kinds from mechanical to electric driving, and

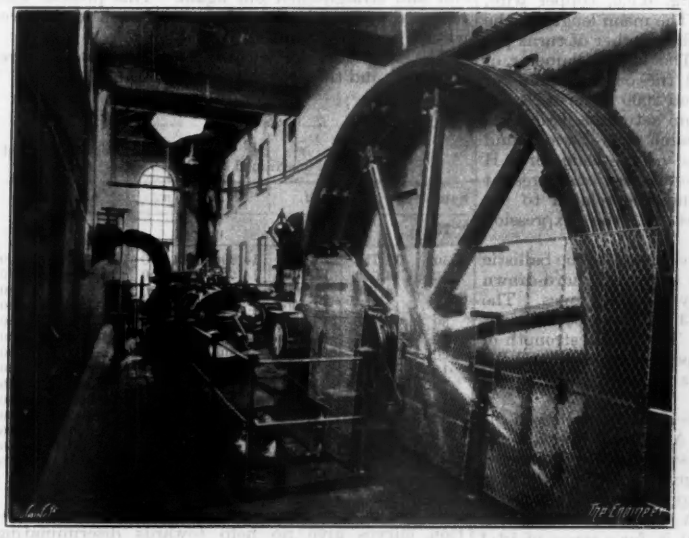


FIG. 39—ORIGINAL 500 H.P. ENGINE DRIVE

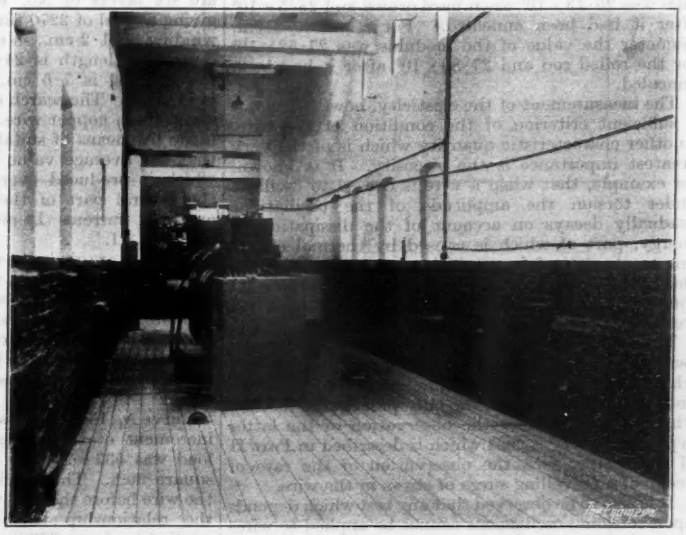


FIG. 40—ENGINE-ROOM CONVERTED TO SUB-STATION

motors are built in all sizes up to about 500 h.p. at 1500 r.p.m. and with higher ratings at lower speeds. They are supplied for single, two, or three-phase circuits up to 600 volts and for horizontal or vertical operation.

But reverting to speed regulation, the Scherbius

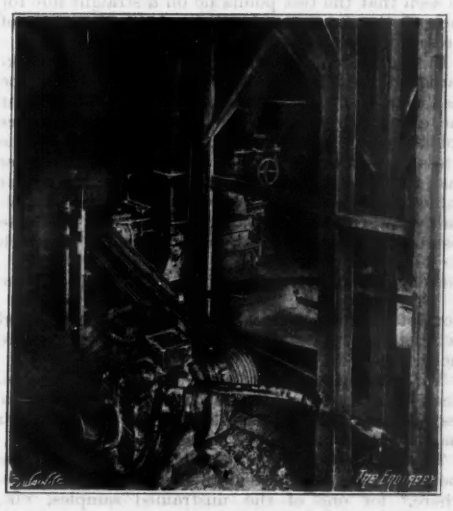


FIG. 38—SLIP-RING MOTOR DRIVING A GRINDING MILL

system is said to have proved in many cases the best and cheapest for large outputs. It has been applied extensively by the General Electric Company of America in connection with the operation of large rolling mills and gives easy operation and good commutation for the use of commutating poles and com-

To obtain the same original speed when a change is made from 25 to 50 cycles the number of poles must be doubled. This, as already shown, can readily be done with a single stator winding arranged so that by changing the connections the number of poles can be increased from, say, four to eight. A dual frequency 25–50 cycle motor therefore consists of a machine in which the stator winding in the case of a squirrel-cage motor and both the stator and rotor winding of a slip-ring motor are arranged so that the number of poles can be doubled by altering the connections at the terminals. But the problem is more difficult when the motor designer has to meet the case of a change from 40–50 cycles. No simple method of pole changing can be used. Moreover, only two of the synchronous speeds met with in usual practice, *i.e.*, 600 and 300 r.p.m., are common to both frequencies. Several other speeds between these two are, however, near enough for practical purposes. Above 800 r.p.m. the differences are comparatively wide. The problem of securing the correct speed when the frequency is raised can be dealt with in two ways. The 25 per cent. increase in speed when the motor is run on 50 cycles can be compensated by fitting a smaller pulley, chain sprocket or gear, although in some cases the higher speed may not be objectionable and mechanical changes may be unnecessary.

The alternative method, applicable to new installations, is to design the motor in the first place so that when the change over is made the machine can be dismantled and the coils regrouped to give as nearly as possible 25 per cent. more poles. A dual frequency motor for 25–50 cycles is illustrated in Fig. 37, which shows a squirrel-cage machine made by the Brush Electrical Engineering Company driving a Brush valve homogeniser at the United Counties Dairies, Birmingham. The illustration—Fig. 38—shows a G.E.C. ordinary single frequency slip-ring motor driving a grinding mill through a Texrope drive at the works of the British Plaster Board Company, Ltd. Dual-frequency motors are made by the G.E.C., the

the advantages secured have been emphasised. This side of the subject scarcely need be elaborated, but the illustrations Figs. 39–41 are reproduced to indicate what can be accomplished in a short space of time. They relate to a weaving shed, which was converted from mechanical to electric driving by the Metropolitan-Vickers Electrical Company, Ltd. Originally the drive consisted of the 500 h.p. horizontal engine, shown in Fig. 39, which was removed and replaced by the 500 h.p. slip-ring motor shown in Fig. 41, which drives the existing line shaft at 124 r.p.m. by means of a bush roller chain. The engine-house has been converted into the weaving shed sub-station—Fig. 40—and the complete change over is said to have been carried out in ten days. The work included the installation of approximately 200 motors, replacing other steam plant and existing motors of non-standard frequency.

(To be continued.)

THE launch took place on August 30th of the twin-screw passenger and cargo liner "Umtata" at the Neptune Yard of Swan, Hunter and Wigham Richardson, Ltd. The vessel is for service on the Natal line of Bullard King and Co., Ltd., of London. She was named by Mrs. Robertson F. Gibb, the wife of the chairman of the Union Castle Mail Steam Ship Company, Ltd., and of Bullard King and Co., Ltd. The vessel is equipped with insulated holds for the carriage of dairy produce, and two methyl chloride electric marine-type refrigerating plants are installed. The insulation in the provision rooms will be on the Bandall system. About 100 first-class passengers will be carried. The machinery, built at the Neptune Engine Works of the shipbuilders, will consist of two triple-expansion sets with Bauer-Wach exhaust turbines. Four boilers will supply steam at 225 lb. per square inch pressure arranged for coal burning, with forced draught and a Howden air preheater. Superheat to 200 deg. Fah. will be provided. An order has been placed with the makers for a sister ship to the "Umtata."

Electro-Magnetic Tests for Work-Hardening Steel Wires.

By T. F. WALL, D.Sc., D.Eng.

Introduction.

THE immediate purpose of the investigations which are described in this paper was to provide means for observing the changes of elasticity and viscosity of the steel wires of colliery winding and haulage ropes after they had been in service, for it has long been recognised that the so-called "work hardening" of a wire rope is as great a menace to its safety as the actual mechanical fracture of a group of the component wires of the rope.

The measurement of the value of Young's modulus by the statical method of direct stretching is, in general, not possible in the case of wires which have been assembled in a rope, since such wires acquire a permanent set by the distortion into a spiral form, and, moreover, when the rope has been in service for some time, some of the wires become irregularly worn, and when wires are in this condition they cannot be used for the measurement of Young's modulus by any of the normal static methods.

Goodman[1] has recorded a series of tests on steel wires in which the value of Young's modulus was measured for wires of different diameters, all made from the same billet of steel, and it was found that in every case the hard-drawn steel wires had a lower value for the modulus than the same wire after it had been annealed. For a wire 0·160in. diameter, the value of the modulus expressed in lb. per square inch was $25{\cdot}43\times10^6$ when hard drawn and $28{\cdot}5\times10^6$ after it had been annealed. For a rod 0·210in. diameter the value of the modulus was $27{\cdot}52\times10^6$ for the rolled rod and $27{\cdot}80\times10^6$ after it had been annealed.

The measurement of the elasticity, however, is not a sufficient criterion of the condition of the wire. Another characteristic quantity which is of the very greatest importance is the viscosity. It is known, for example, that when a wire is caused to oscillate under torsion the amplitude of the oscillations gradually decays on account of the dissipation of energy, part of which is caused by thermal effects due to changes of form which occur even when the elasticity is perfect,[2] and Lord Kelvin[3] has recorded some notable experimental results which he obtained from the measurement of torsional oscillations.

The viscosity which is associated with torsional oscillations, however, is not the same as the viscosity which is associated with simple longitudinal stresses, and in so far as known, the only practicable method which is available for the observation of the latter type of viscosity is that which is described in Part II of this paper, viz., the observation of the rate of decay of a travelling surge of stress in the wire.

It is also to be observed that any test which depends upon torsional oscillations cannot be applied to wires which have a permanent set or are partly or irregularly worn, such as occurs in the case of wires of a rope which has been in service for some time.

Methods which involve the magneto-striction effect have been developed by the author[4] for measuring the value of Young's modulus of a wire by means of longitudinal vibrations, and also by the direct measurement of the speed at which a surge of stress travels along the wire. By observing the rate at which the magnitude of the surge decays as it travels, a measure of the viscosity is obtained.

The electro-magnetic methods described in this paper fall into two classes, viz. (i) a ballistic magneto-striction method and (ii) a method for recording the speed of travel and the rate of decay of a surge of stress in the wire.

Part I.: Ballistic Magneto-Striction Method.

It was shown by Joule[5] that a bar of iron changes its length when magnetised, and Ewing[6] showed by magnetometer measurements that when an iron wire which had been stretched beyond its elastic limit was placed in a magnetic field and then loaded, very large increases of magnetic induction due to the loading could be obtained. For annealed iron wire, however, the effect was found to be very much less.

Ordinary permeability tests do not permit of any reliable discrimination between a wire which is in its normal unstrained condition and a similar wire which has been severely overstrained. This is evident from the results recorded in Table I, which is given below.

The principle of the ballistic magneto-striction method has been outlined elsewhere.[7] The test consists essentially in magnetising the wire to a known value of H and then applying a load to the wire. The increase of induction in the wire due to the application of the load is measured by the throw on a ballistic galvanometer. If this procedure be followed for a given value of the load, and a range of values of the magnetising force H, the relationship between the increment of the induction B and the magnetising force will be a curve such as that shown in Fig. 1. In making this test it is important to observe that before each ballistic measurement is made the load is to be released and the wire is to be brought into a cyclic magnetic state by the well-known method of reversals, commencing with a high value of the magnetisation and gradually reducing this value until the desired magnitude of H has been reached.

A further precaution which is necessary is as follows:—For each value of the magnetising force H a ballistic measurement is made when the magnetisation is in one direction and the whole procedure is then repeated for the magnetisation of the wire in the opposite direction, the mean of the two ballistic measurements being taken to be the value of the increment of the induction Δ B, which corresponds to that value of H.

The leading particulars of the magnetising solenoid which was used in these tests are as follows:—There are six layers of No. 16 s.w.g. d.c.c. copper wire, giving a total of 2270 turns. The mean length of the winding is 91·2 cm., so that the number of turns per centimetre length is 24·9. The inside diameter of the winding is 7·6 cm., and the outside diameter is 11·5 cm. The search coil had 2000 turns of No. 36 s.w.g. d.c.c. copper wire. From actual ballistic tests made by means of suitable search coils it was found that the average value of the magnetising force H which is produced over the cross-sectional area at the central part of the solenoid is related to the exciting current I ampères by the expression $H=29{\cdot}7\times I$.

In Fig. 1 are given the results of some of the ballistic magneto-striction tests for a sample of hard-drawn steel wire as used in colliery winding ropes. The diameter of the wire was 0·123in., the carbon content being 0·70 to 0·75 per cent. The tensile strength of the wire was 100 to 110 tons per square inch, and the result of the torsion test was 28 turns on a length of 8in.

Curve A_1, Fig. 1, shows the relationship between the increment of the induction Δ B when the applied load was 533 lb.—that is, a stress of 19·8 tons per square inch. The abscissæ give the values of H in the wire before the load was applied. Curve A_2 shows the relationship between Δ B and H when the applied load was 330 lb.—that is, for a stress of 12·1 tons per square inch—and Curve A_3 shows the corresponding results when the applied load was 120 lb.—that is, for a stress of 4·4 tons per square inch.

The characteristic feature of each of these curves is that for small and moderate values of H the value of Δ B increases with H; that is to say, the permeability of the wire is increased by the application of the load. After passing through a maximum, the value of Δ B then decreases with increasing values of H, so that each curve eventually crosses the abscissa axis and becomes negative. For high values of H therefore the application of the load produces a diminution of the permeability. The value of H for which the curve crosses the abscissa axis is not the same as the Villari reversal point which refers to steady loading, and the distinction will be clear by reference to the test data to which Fig. 3 refers.

If the crest values of the curves in Fig. 1 are plotted as a function of the load, it is found that the points so obtained lie on a straight line for a wide range of values of the load, as is shown by the full line in Fig. 2. After a load of 540 lb. had been left on continuously for 16½ hours, and then removed, curves corresponding to those in Fig. 1 were obtained, and the crest values were again plotted as a function of the stress. The results are shown by the broken line in Fig. 2, from which it will be seen that the straight line relationship still holds for a wide range of the stress, but the slope of the line is now greater than that previously obtained, and shown by the full line in Fig. 2. In other words, loading the wire for 16½ hours with a stress of 19·9 tons per square inch would appear to produce some permanent strain, although the stress to which this is due is relatively small. This ballistic magneto-striction test therefore provides a very sensitive means for detecting small effects of loading which cannot be detected in any other way.

It is of interest to compare the changes in induction due to loading the sample under the conditions already specified for the ballistic magneto-striction test, and the effect on the permeability due to a steady load on the sample. The curves shown in Fig. 3 give this comparison, and they refer to the same sample of wire as those of Fig. 1. The curve *a*, Fig. 3, gives the relationship between B and H for the unloaded wire, the measurements having been made by the method of reversals in the usual way. The curve *b* in Fig. 3 gives the relationship between B and H when the wire is loaded steadily with a weight of 533 lb., the measurements for this curve having also been obtained by the method of reversals. The point at which the two curves *a* and *b* cross is the Villari reversal point for the load of 533 lb. The curve *c* has been obtained by adding corresponding ordinates for the curve *a*, Fig. 3, and the curve A, Fig. 1. The striking feature of the curve *c* is that although it refers to the same load as the curve *b* it shows immensely higher values for the permeability than the curve *b*, so that by applying a load to steel wire which is already situated in a magnetic field, a much larger increase of permeability is obtained than when the wire is steadily loaded with the same weight and the permeability measurements are made by the method of reversals in the usual way. Moreover, the curves *a* and *c* cross for H=34, whereas the curves *a* and *b* cross for the much lower value of H=9·5, this latter point of crossing being the Villari reversal point for this load.

Tests on Wire Samples Work-hardened by Severe Bending Stresses.

In order to apply the ballistic magneto-striction test to show the effect of work hardening, Wrights' Ropes, Ltd., supplied six samples of hard-drawn steel wire of diameter 0·116in. These samples were labelled respectively *a*, *b*, *c*, *d*, *e*, and *f*. Four of these wires, viz., *a*, *c*, *d*, and *e*, were supplied in the normal unstrained condition, whilst two, viz., *b* and *f*, were work-hardened by the following procedure. Each wire was wrapped on a pulley 3½in. diameter, giving a lap of 180 deg., and was then drawn from end to end and straightened out again. This process was repeated twelve times in the case of each of the two wires *b* and *f*.

The magnetisation curves for all six wires were obtained, and the data are shown in Table I.

Table I.

	Normal unstrained samples.				Work-hardened samples.	
Sample	*c.*	*d.*	*e.*	*a.*	*b.*	*f.*
H.	B.					
50	14,750	14,600	14,900	14,700	14,900	14,500
45	14,500	14,300	14,500	14,300	14,600	14,200
40	14,100	13,800	14,100	13,800	14,200	13,800
35	13,600	13,200	13,450	13,100	13,700	13,300
30	12,900	12,300	12,500	12,300	12,900	12,500
25	11,600	11,000	11,100	10,900	11,700	11,300
20	9,200	8,600	8,800	8,500	9,400	9,100
18	7,600	7,000	7,200	7,000	8,200	7,700
16	6,000	5,200	5,600	5,200	6,500	5,900
14	4,300	3,500	3,800	3,400	4,500	4,200
12	2,600	2,300	2,400	2,100	2,800	2,400
10	1,700	1,300	1,400	1,300	1,500	1,200
8	950	800	900	800	900	650
6	500	500	500	450	450	370

It will be seen from this table that the magnetisation curves give no help towards discriminating between the unstrained wires and the work-hardened wires.

Ballistic magneto-striction tests were then made by the method already fully described, and the results are shown in Figs. 4 and 5. In Fig. 4 are given the results for the four normal unstrained samples *a*, *c*, *d*, and *e*, the crest values of the Δ B: H curves having been plotted as a function of the load by means of curves similar to those given in Fig. 1. It will be seen that the test points lie on a straight line for each of the four samples throughout the range of stress up to about 22 tons per square inch.

In Fig. 5 are shown the results for the two work-hardened samples *b* and *f* respectively. It will be seen that, except for a very small range of stress near the origin, the straight line relationship no longer holds for these samples. For the lower values of the stress the curves in Fig. 5 are considerably higher than the straight lines of Fig. 4, whilst for the higher values of the stress the curves of Fig. 5 lie appreciably lower than the straight lines of Fig. 4. These results are more clearly shown in Fig. 6, in which the slope $\frac{d}{d\,s}(\Delta\,B)$ of the curve *f* in Fig. 5 and the slope of each of the straight lines in Fig. 4 are plotted as functions of the stress *s* measured in tons per square inch.

The effect of work-hardening the wire is, therefore, clearly shown to result in a relatively greater magnetic response to small stresses and a relatively smaller magnetic response to large stresses.

The values of Young's modulus were found by the method of longitudinal vibration as described elsewhere,[8] for one of the unstrained samples, viz., sample (*e*), and for the two work-hardened samples (*b*) and (*f*). The results are as follows:—

Sample (*e*): Young's modulus, 21×10^{11} dynes per square centimetre.

Sample (*b*): Young's modulus, $8{\cdot}2\times10^{11}$ dynes per square centimetre.

Sample (*f*): Young's modulus, $14{\cdot}8\times10^{11}$ dynes per square centimetre.

[1] J. Goodman, "Mechanics Applied to Engineering," ninth edition, Vol. I, page 380.

[2] P. G. Tait, "Properties of Matter," fourth edition, page 231.

[3] "Encyclopædia Britannica," ninth edition, Vol. 7, article on "Elasticity."

[4] *Nature*, 1933, Vol. 131, page 351; also 1934, Vol. 133, page 418; *Journal*, Institution of Electrical Engineers, December, 1934.

[5] J. P. Joule, *Phil. Mag.*, 1847, Vol. 30.

[6] J. A. Ewing, *Phil. Trans.*, 1885.

[7] *Nature*, 1933, Vol. 132, page 513.

[8] *Journal*, Institution of Electrical Engineers, December, 1934.

It is apparent from these results that the work hardening of the samples (*b*) and (*f*) has completely destroyed their mechanical reliability.

TESTS ON WORK-HARDENED WIRES TAKEN OUT OF COLLIERY HAULAGE ROPES.

As a further illustration of the application of the ballistic magneto-striction tests to the detection of work hardening, the following results were obtained from wires supplied by Mr. A. C. F. Assinder, managing director of the New Monckton Collieries, Ltd., Barnsley. The wires were each 0·116in. diameter and were taken out of belt ropes working endless haulage, 1200 yards long, and 1¼in. overall diameter, the rope being of "Lang's Lay" formation. Two of the wires were taken out of a rope which had been in service for two years, and two of the wires were taken out of an exactly similar new rope which had not then been put into service.

The results of the ballistic magneto-striction tests are shown in Fig. 7. It will be seen that the curves referring to the wires from the new ropes are well separated from those which refer to the wires from the old ropes. For the new wires the straight line relation ship holds for stresses up to about 16 tons per square inch, whilst for the old wires the straight line relationship holds only for a range of stress up to about 5 tons per square inch. It is, however, apparent that even the new wires show considerable evidence of work hardening, since the straight line relationship holds only so far as about 16 tons per square inch, whilst for the similar type of normal unstrained rope wire shown in Fig. 2 the straight line relationship holds for a range of stress up to about 22 tons per square inch. It is to be observed that the wires from the new rope had a very marked permanent set due to the formation of the rope, and if these new wires were allowed to assume their natural form they showed very clearly the spiral formation into which they had been forced when the rope was built up. The extremely important result is, therefore, disclosed that, owing to the very large stresses to which these new wires have been subjected when the rope was constructed, they might have been expected to exhibit the signs of over-strain which the test results given in Fig. 7 do in fact disclose. As will be seen in the test results which are recorded in Part II, this conclusion is confirmed by the rate of decay of a travelling surge of stress, and these new wires are evidently in an advanced stage of deterioration, so that even before the rope has been put into service the mechanical properties have been most seriously impaired.

PART II: THE OBSERVATION OF A TRAVELLING SURGE OF STRESS IN THE WIRE.

Information of a kind which cannot be obtained in any other known way as to the condition of the material of a wire is disclosed by the study of travelling surges of stress in the wire. A preliminary note on this method has been published already.[1] From the results which are recorded in the following it will be seen that this method provides means for the observation of work hardening and overstrain. The method also provides means for measuring Young's modulus in wires which are distorted or deformed in such a way that the method of longitudinal vibrations is difficult to apply and the direct method of static elongation is impossible.

Briefly stated, the procedure is as follows. The test requires a length of wire of not less than about 100ft. The wire is passed through a series of three or four solenoids spaced at about equal distances along the wire. At the centre of each solenoid is arranged a search coil. All the solenoids are connected so that the exciting coils are in series with one another. All the search coils are also connected in series with each other and through a valve amplifier to an oscillograph. The wire is suitably clamped at one end and a blow is struck on that end of the wire so that a surge stress is started, and this surge will then travel along the wire with the speed of sound *v* cm. per second.

As the surge passes through each solenoid it gives rise to an E.M.F. in the corresponding search coil, and this E.M.F. is recorded on the oscillogram. As the surge travels it decays in magnitude and the induced E.M.F. in the respective search coils will also decay accordingly. The rate of decay of the surge of stress will be logarithmic, but reference to the curve given in Fig. 1 shows that the stress and increment of flux density are not proportional for every value of the magnetising force. If oscillograms of the travel of a surge are taken, however, for a series of values of the magnetising force, that oscillogram which shows the magnitude of the induced E.M.F.'s in the search coils to decay logarithmically will give the rate of decay of the magnitude of the surge itself.

If $\bar{\theta}$ is the magnitude of the peak E.M.F. recorded by the search coil of the first solenoid, then the magnitude θ of the peak E.M.F. given by any one of the other solenoids distant D feet from the first may be written

$$\theta = \bar{\theta} e^{-kD}$$

when the decay of the peak magnitudes is logarithmic.

If t seconds is the time taken for the surge to pass between any two solenoids distant x cm. apart, the velocity of the surge will be

$$v = x/t \text{ cm. per second,}$$

so that the value of Young's modulus will be given by the equation

$$E = v^2 \rho \text{ dynes per square centimetre,}$$

where ρ is the density of the material of the wire in grammes per cubic centimetre.

The time scale in all the oscillograms was provided by a 500 frequency standard tuning fork, which was electrically maintained in vibration in the well-known manner.

RESULTS OF TESTS.

A.—Normal Steel Wire.

For these tests wire as used in the construction of colliery winding ropes was obtained from Latch and Batchelor, Ltd., who also supplied the data of the physical tests.

(i) One roll of wire, 0·125in. diameter, in the hardened "as-drawn" condition, was tested, the physical test data of the wire being as follows:—

Breaking strength in tons per sq. inch.	Torsion test on a length of 8in.	Brinell hardness test.
117	25	430

The analysis of the material gave the following composition:—Carbon, 0·76 per cent.; manganese, 0·59 per cent.; silicon, 0·19 per cent.; phosphorus, 0·021 per cent.; sulphur, 0·007 per cent. The material received a total reduction of 75 per cent.

[1] *Nature*, Vol. 133, 1934, page 418.

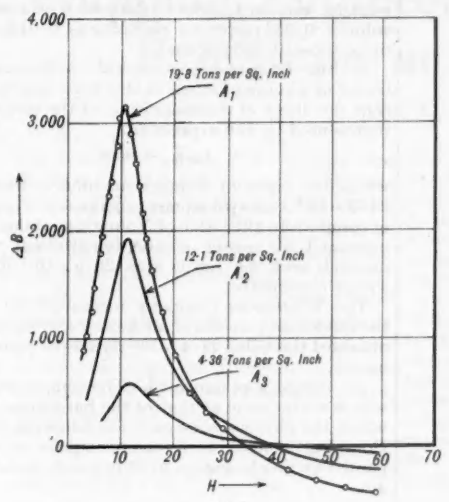


FIG. 1

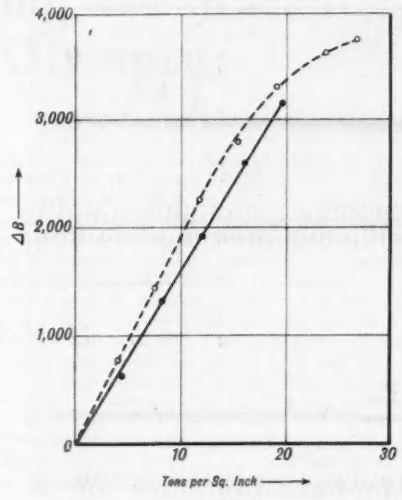


FIG. 2

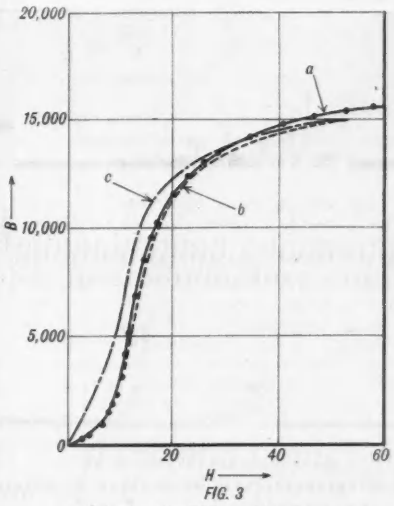


FIG. 3

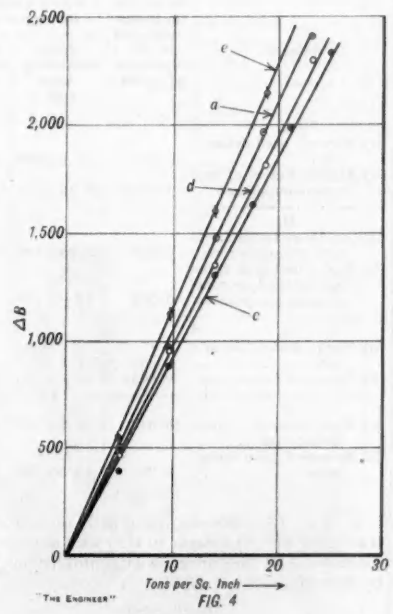


FIG. 4

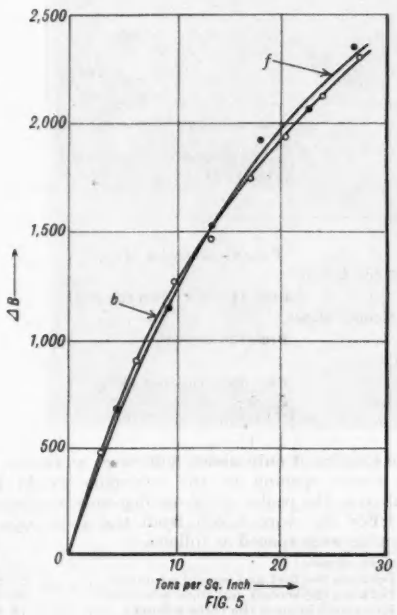


FIG. 5

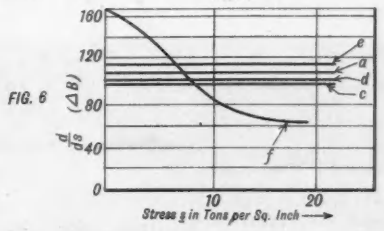


FIG. 6

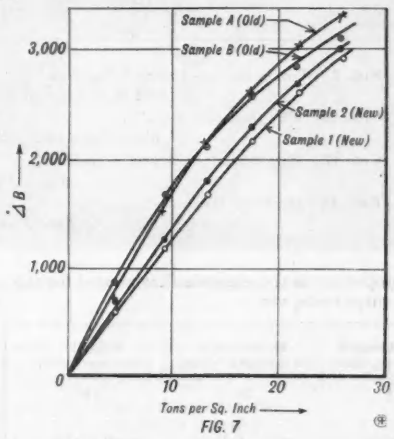


FIG. 7

The total length of wire measured from the middle of the first solenoid was 453·8ft., and this length was made up as follows :—

Length of wire :	
Between the first and second solenoids	132·2ft.
Between the second and third solenoids	136·0ft.
Between the third and fourth solenoids	138·0ft.
Extending beyond the fourth solenoid	47·6ft.

In Fig. 8 is shown a typical oscillogram of the travel of a surge of stress in this wire, from which it is found that the rate of decay is given by the expression :—

$$\theta = \bar{\theta}\, e^{-0.0051\,D}$$

when the distance D is measured in feet, and the value of Young's modulus as deduced from the speed of travel of the surge is $20{\cdot}1 \times 10^{11}$ dynes per square centimetre, or $29{\cdot}2 \times 10^{6}$ lb. per square inch.

For purposes of comparison the frequency of longitudinal vibration of a known length of wire was measured by the method which has been described elsewhere. The wire was 0·122in. diameter and was supplied by the same makers, being of almost identical physical properties as the wire which was used for the travelling surge tests, viz.:—

Breaking strength in tons per sq. inch.	Torsion test on a length of 8in.	Brinell hardness test.
125¼	26	460

The analysis gave the following composition :—Carbon, 0·81 per cent.; manganese, 0·39 per cent.; silicon, 0·18 per cent.; phosphorus, 0·020 per cent.; sulphur, 0·007 per cent. The reduction received by this wire was 75 per cent.

The value of Young's modulus as found by this test was $20{\cdot}8 \times 10^{11}$ dynes per square centimetre.

(ii) A roll of the same wire as that described in (i) and of diameter 0·125in. was obtained in the annealed condition, the physical test data being as follows :—

Breaking strength in tons per sq. inch.	Torsion test on a length of 8in.	Brinell hardness test.
50¼	44	235

In Fig. 9 is shown a typical oscillogram of the travel of a surge of stress in this wire and the rate of decay of the magnitude of the surge is found to be given by the expression :—

$$\theta = \bar{\theta}\, e^{-0.0065\,D}$$

The value of Young's modulus as found from the oscillogram of Fig. 9 is $20{\cdot}35 \times 10^{11}$ dynes per square centimetre.

In this case also the value of Young's modulus was measured by the method of longitudinal vibration and was found to be $21{\cdot}5 \times 10^{11}$ dynes per square centimetre, the test being made on an annealed wire of very similar physical characteristics to the one just specified and supplied by the same makers. The physical tests on this sample gave the following results :—

Breaking strength in tons per sq. inch.	Torsion test on a length of 8in.	Brinell hardness test.
44¾	59	217

The composition of the wire was the same as that given in (i) above for the hard-drawn wire of 0·122in. diameter.

B.—Steel Wires taken from Colliery Haulage Ropes.

Oscillograms of travelling surges of stress were taken for wires which were taken from endless haulage ropes in the New Monckton Colliery near Barnsley, as already referred to in the test results given in Part I of this paper.

For these tests only three solenoids were used, since lengths of only about 80ft. were available, and any closer spacing of the solenoids would have resulted in the peaks of the oscillograms overlapping.

(i) For the wire taken from the new rope the solenoids were spaced as follows :—

Length of wire :	
Between the first and second solenoids	27·9ft.
Between the second and third solenoids	38·1ft.
Extending beyond the third solenoid	18·0ft.

In Fig. 10 is shown a typical oscillogram of a travelling surge of stress. The first solenoid gives a double peak effect, whilst the fourth and fifth peaks are due to the reflection of the surge at the open end of the wire returning through the third and second solenoids respectively.

The oscillograms show that the decay of the magnitude of the surge may be represented by the expression :—

$$\theta = \bar{\theta}\, e^{-0.019\,D}$$

whilst the value of Young's modulus is found to be $18{\cdot}85 \times 10^{11}$ dynes per square centimetre.

These results show that, although this wire has never been in service, it is already badly strained, due to the permanent set which it has obtained when being built into the rope. These conclusions confirm the results obtained in Part I by means of the ballistic magneto-striction tests—see Fig. 7.

(ii) For the wire taken from the old rope which had been in service for two years the solenoids were spaced as follows :—

Length of wire :	
Between the first and second solenoids	34·46ft.
Between the second and third solenoids	24·25ft.
Extending beyond the third solenoid	17·60ft.

In Fig. 11 is shown a typical oscillogram of a travelling surge of stress in this wire. A number of such oscillograms were taken, and it was found that the decay of the magnitude of the travelling surge of stress may be represented by the expression :—

$$\theta = \bar{\theta}\, e^{-0.014\,D}$$

whilst the value of Young's modulus is now $13{\cdot}6 \times 10^{11}$ dynes per square centimetre.

The remarkable fact emerges from these tests that the wire which has been in service for two years has an appreciably smaller decay coefficient than the wire taken from the new rope, from which it is seen that working the wire in service hardens it to a striking extent. The value of Young's modulus for this old wire, however, has been reduced to an extremely low figure, from which it is clear that the old rope must be in a dangerous condition of deterioration.

C.—Armco Wire.

(i) Armco wire in the hardened "as-drawn" condition. This wire was ¼in. diameter and was supplied by the Whitecross Company. The breaking strength was 43 tons per square inch and was accompanied by an elongation of 2·7 per cent. on 4in. The composition was as follows :—Carbon, 0·025 per cent.; sulphur, 0·032 per cent.; phosphorus, 0·015 per cent.; manganese, 0·035 per cent.

In Fig. 12 is shown a typical oscillogram of the travel of a surge of stress in this wire, and it is found that the decay of the magnitude of the surge may be represented by the expression

$$\theta = \bar{\theta}\, e^{-0.0035D}$$

whilst the value of Young's modulus is found to be $21{\cdot}3 \times 10^{11}$ dynes per square centimetre. For purposes of comparison the value of Young's modulus was also measured by means of the longitudinal vibration method, and the result was $20{\cdot}5 \times 10^{11}$ dynes per square centimetre.

The Whitecross Company measured the value of the modulus by means of an Amsler extensometer and obtained the value $21{\cdot}4 \times 10^{11}$ dynes per square centimetre.

(ii) Armco wire annealed. The composition of this wire was the same as that of the hard-drawn sample, whilst the physical tests gave the following results :—Breaking strength, 21·6 tons per square inch, accompanied by an elongation of 37 per cent. on a length of 4in.

TABLE II.

Material.	Value of k the decay coefficient in the expression $\theta = \bar{\theta} e^{-kD}$	Young's modulus in dynes per sq. cm.	
		From travelling surge test.	From the longitudinal vibration test.
A.			
(i) Normal hard-drawn steel	0·0051	$20{\cdot}1 \times 10^{11}$	$20{\cdot}8 \times 10^{11}$
(ii) Annealed steel of the same composition	0·0065	$20{\cdot}35 \times 10^{11}$	$21{\cdot}5 \times 10^{11}$
B.			
(i) Steel wire taken from a new haulage rope	0·019	$18{\cdot}85 \times 10^{11}$	—
(ii) Steel wire taken from an old haulage rope of same composition	0·014	$13{\cdot}6 \times 10^{11}$	—
C.			
(i) Hard-drawn Armco wire	0·0035	$21{\cdot}3 \times 10^{11}$	$20{\cdot}5 \times 10^{11}$
(ii) Annealed Armco wire	0·0051	$20{\cdot}3 \times 10^{11}$	$20{\cdot}6 \times 10^{11}$
D.			
(i) Hard-drawn pure nickel wire	0·016	$22{\cdot}3 \times 10^{11}$	$23{\cdot}9 \times 10^{11}$
(ii) Annealed pure nickel wire	0·032	$19{\cdot}8 \times 10^{11}$	$20{\cdot}9 \times 10^{11}$

In Fig. 13 is shown a typical oscillogram of the travelling surge of stress in this wire and the decay of magnitude of the surge was found to be expressed by the equation

$$\theta = \bar{\theta}\, e^{-0.0051\,D}$$

whilst the value of Young's modulus, as found from this oscillogram, is $20{\cdot}3 \times 10^{11}$ dynes per square centimetre. The value of the modulus as obtained from the vibration test was $20{\cdot}6 \times 10^{11}$ dynes per square centimetre, and the value found by the Amsler extensometer was $21{\cdot}4 \times 10^{11}$ dynes per square centimetre.

D. Pure Nickel Wire.

(i) Pure Nickel Wire : Hard-drawn.

For this test the four solenoids were spaced as follows :—

Length of wire :	
Between the first and second solenoids	37·7ft.
Between the second and third solenoids	35·9ft.
Between the third and fourth solenoids	35·7ft.
Extending beyond the fourth solenoid	22·9ft.

In Fig. 14 is shown a typical oscillogram of a travelling surge of stress, and it is found that the decay of the magnitude of the surge is given by the expression

$$\theta = \bar{\theta}\, e^{-0.016\,D}$$

The value of Young's modulus, as measured from the oscillogram, is $22{\cdot}3 \times 10^{11}$ dynes per square centimetre, the density of the wire being 8·9.

The value of Young's modulus, as found by the

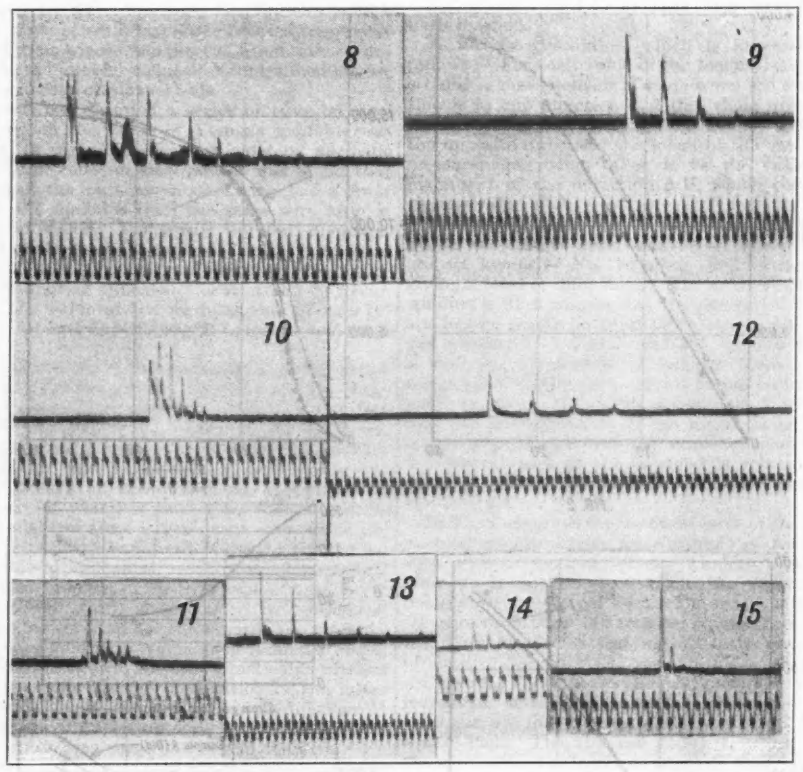


FIG. 8—*Wire in the "As Drawn" Condition.* FIG. 9—*Annealed Wire.*
Steel Wire Supplied by Latch and Batchelor.
FIG. 10—*Wire from New Rope.* FIG. 11—*Wire from Old Rope.*
Wires Taken from Colliery Haulage Ropes.
FIG. 12—*Wire in the "As Drawn" Condition.* FIG. 13—*Annealed Wire.*
Armco Iron Wire.
FIG. 14—*Hardened Wire.* FIG. 15—*Annealed Wire.*
Pure Nickel Wire.

method of longitudinal vibration, was $23{\cdot}9\times10^{11}$ dynes per square centimetre.

(ii) Pure Nickel Wire : Annealed.

Pure nickel wire in the dead soft condition was obtained of ¼in. diameter. Owing to the very heavy damping which is characteristic of pure nickel wire in this condition, only three solenoids were used and spaced as follows :—

Length of wire :
Between the first and second solenoids .. .. 34·8ft.
Between the second and third solenoids .. .. 34·2ft.

The oscillogram shown in Fig. 15 is typical of the travelling surge for this wire, and it is found that the decay of the magnitude of the surge is given by the expression

$$\theta=\bar{\theta}\,e^{-0{\cdot}032\,D}$$

whilst the value of Young's modulus, as found from this oscillogram, is $19{\cdot}8\times10^{11}$ dynes per square centimetre. The density of the wire is 8·9 grammes per cubic centimetre, and measurements of the frequency of longitudinal vibration gave the value of $20{\cdot}9\times10^{11}$ dynes per square centimetre for Young's modulus.

It will be seen from Table II that the value of the damping coefficient k is considerably less for hard-drawn Armco wire than for any of the other materials examined. Further, with the exception of hard-drawn Armco wire, the value of Young's modulus, as measured by the travelling surge test, is considerably less than the value obtained by the longitudinal vibration test. Another striking result is the difference between the values of the modulus for nickel wire when in the hard-drawn and the annealed conditions respectively, the value for hard-drawn nickel wire being about 15 per cent. greater than the value for the annealed wire.

The investigation was carried out in the electrical engineering department of the University of Sheffield

The Shipping, Engineering and Machinery Exhibition at Olympia.

No. I.

WITH this issue we publish two Supplements dealing with the exhibits at the thirteenth Shipping, Engineering and Machinery Exhibition, which was opened yesterday at Olympia, London. Our descriptive articles will be continued next week in another Supplement, and, as long as the Exhibition remains open, in the body of the paper also. It is our hope that these articles will help to guide intending visitors to the Show and to inform those less fortunate as to how engineering design and construction has progressed in the two years which have elapsed since the last Exhibition was held.

SHELL-MEX AND B.P., LTD.

Although great developments have taken place in recent years in oil engines and a greatly increased knowledge has been acquired of the technical side of their design and operation, there still appears to be quite a widespread belief that these engines will run on practically any kind of oil fuel. That is very far from the truth. It is agreed that the larger types of slow-speed engines can, and do, run on a fairly wide range of fuels, but the small and higher speed

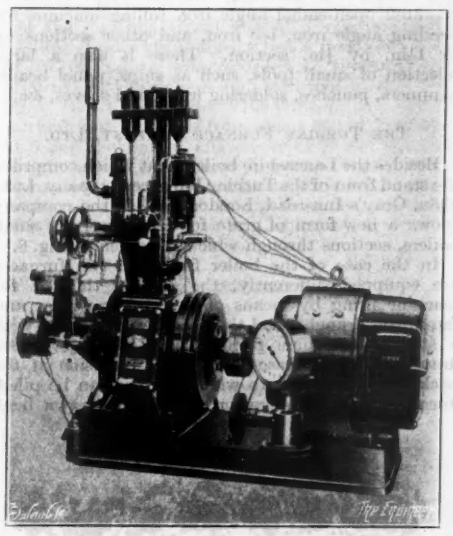


FIG. 1—FUEL TESTING ENGINE—SHELL-MEX

types, which are becoming increasingly popular for industrial purposes, rail traction, and agricultural and marine work, are exceedingly exacting in their requirements. The essential characteristics of a good oil fuel may be grouped under three headings : Suitable physical characteristics ; correct ignition quality ; and freedom from contamination. Of these three, ignition quality is the most elusive and difficult to determine. It cannot be determined by any known laboratory test, but can only be satisfactorily examined by taking careful records of the behaviour of the fuel in the engine itself. With the present types of engines it is desirable, for two important reasons, to use only those fuels which start to burn quickly. The delay period between injection and ignition is thereby reduced, eliminating combustion shock arising from the uncontrolled burning of the excess amount of fuel entering the cylinder prior to ignition, and ease in starting under varying climatic conditions is obtained.

The Sunbury electrical indicator has been designed and developed in the research laboratory of the Anglo-Iranian Oil Company, Ltd., and it is in regular use for investigating such problems in connection with fuel research and engine design. The indicator can also be used for examining the operation of petrol or kerosene engines, and their fuels.

On the stand of Shell-Mex and B.P., Ltd., at Olympia, a Sunbury electrical indicator is coupled to the C.F.R. (Co-operative Fuel Research) oil-fuel-testing engine in operation. This engine (see Fig. 1) has a variable compression head which enables any predetermined compression ratio, between approximately 6½ : 1 and 22 : 1, to be used. It is fitted with a loading generator arranged for running speeds from 600 r.p.m. to 1500 r.p.m. The combustion chamber is of the air-cell type with a cooled throat.

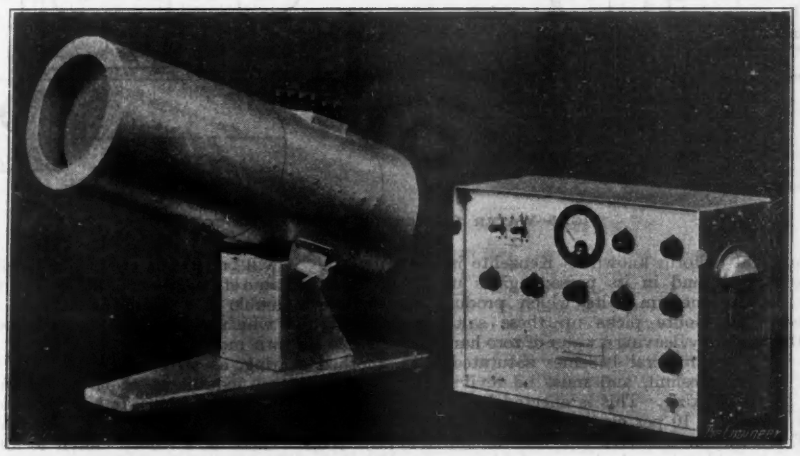


FIG. 2—SUNBURY ELECTRICAL INDICATING APPARATUS—SHELL-MEX

Phenomena in the engine can be observed through the medium of a cathode ray oscillograph.

Fig. 2 is an illustration of the indicating apparatus. One of its essentials is a cathode ray tube of the type developed for television purposes. Such a tube has the faculty of responding instantaneously to any electrical impulse applied to it, and, unlike any mechanical device, is entirely free from inertia effects which may introduce vibrations to mask effects actually taking place in an engine to which it may be applied. When this cathode ray tube is in use, a brilliant spot of light appears on a fluorescent screen at the larger end, and this spot is deflected by any voltages or magnetic forces applied to what are known as the deflecting plates of the tube. It is a comparatively simple matter to arrange a contact breaker driven from the engine crankshaft so that the spot of light travels across the screen along a horizontal line, and so that it has always reached exactly the same place for any given position of the engine shaft. A ripple may be superimposed on this line which marks degrees of crank angle and also shows the top dead centre or any other reference position. For normal fuel-testing purposes the rate of movement of the indicating spot is such that it travels about one-tenth of an inch in a six-thousandth of a second, although either slower or faster rates are easily obtained with a simple control. If a voltage is applied to a second pair of deflecting plates in the tube, the light will move vertically instead of horizontally and, if this separate voltage is one which varies with, say, engine cylinder pressures, the vertical travel will be proportional to the pressures.

By applying both voltages at the same time, a diagram is produced which gives the change of pressure in the cylinder on a crankshaft degree base. Such a diagram is shown in the upper curve of Fig. 3.

In the Sunbury indicator a small and thick diaphragm is used to obtain the second motion. It is mounted in a stout fitting screwed into the engine cylinder. This diaphragm has a natural frequency of about 40,000 cycles per second, and at the highest cylinder pressures has only to move about half a thousandth of an inch. Its inertia effects are thus negligible, and it is practically unaffected as regards behaviour by the temperatures reached in normal working. Its movements follow the pressure changes

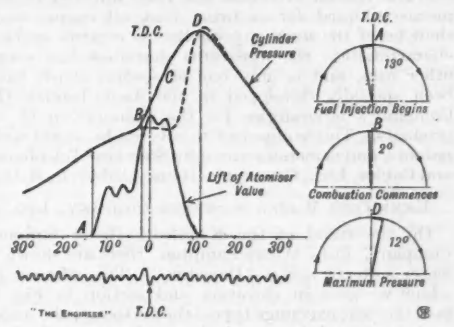


FIG. 3—CURVES OF CYLINDER PRESSURE AND ATOMISER VALVE LIFT

in the cylinder with such rapidity that its rate of movement at any instant is almost exactly the rate of change of pressure in the cylinder. Mounted near to this iron diaphragm, but at an appreciable distance from it in comparison with the maximum deflection, is a small electro-magnet, around the pole of which are wound a few thousand turns of fine wire. Voltages are induced in this coil when the engine is running, which are very closely proportional to the rates of pressure change in the engine cylinder. These voltages are amplified in a special amplifier comparable in construction with a simple wireless receiver and applied to the cathode ray tube.

Such a diagram has many uses and gives data difficult to obtain in other ways, but it is desirable to be able to obtain a record of pressure changes as well as that of rates of change. Mathematically, what is required is an integration of the rate of change diagram, and this object is achieved by introducing a special stage in the amplifier.

A unit similar in general principle is used in the fuel supply pipe to register fuel pressures. A typical diagram is shown in Fig. 4. The fuel pressure starts to rise at A when the fuel pump plunger overruns

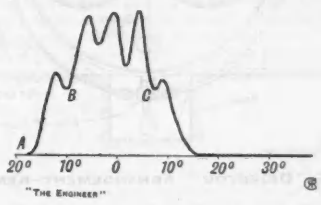


FIG. 4—CURVE OF FUEL PRESSURE

the pump suction port, and the rising pressure is checked at B by the opening of the spray valve. Following this is a series of pressure waves, the frequency of which is determined by the length of the fuel pipe, the atomiser valve closing at C soon after the pump delivery valve closes.

A diagram of the actual movements of the atomiser valve can also be obtained. An example is given in the lower curve of Fig. 3. The top dead centre position is shown by the large ripple and each wave covers 2 deg. of crank movement, or, at the engine

speed at which these tests were made, one three-thousandth of a second.

In this diagram the atomiser begins to lift visibly at A when the crank is 13 deg. before top centre, at B, 2 deg. before top centre, combustion begins, the difference of 11 deg. being known as the delay angle for the fuel. The maximum rate of pressure rise is at C, better determined from a rate of change diagram and being a measure of Diesel knock. The dotted line shows a diagram taken from a low-ignition quality fuel—the delay angle is much longer and the maximum rate of pressure rise is greater, giving more Diesel knock. Such a fuel will also be more liable to lead to starting trouble.

While special attention has been directed to the means adopted for ensuring that all engine fuels shall be of the necessary quality as regards ignition characteristics, the apparatus described has many other uses, and is only one of several which have been specially developed in the Anglo-Iranian Oil Company's laboratories for the examination of its products. This equipment is covered by world-wide patents, and is manufactured by Standard Telephones and Cables, Ltd., Connaught House, Aldwych, W.C.2.

KENNICOTT WATER SOFTENER COMPANY, LTD.

On the stand of the Kennicott Water Softener Company, Ltd., Wolverhampton, there are shown a water softener and a "Dejector." The softener, of which we give an elevation and section in Fig. 5, is of the base exchange type—that is to say, the water to be softened is passed slowly through a bed of zeolite mineral (a form known as Kenzelite is used in these plants), and in its passage gives up the calcium and magnesium salts which produce its hardness. The zeolite picks up these salts and retains them entirely, leaving a water of zero hardness. After a time the mineral becomes saturated with calcium and magnesium, and must be revivified if it is to go on working. This is effected by passing through the bed a 10 per cent. solution of common salt. This solution dissolves out the calcium and magnesium as chlorides, which are soluble in water and can consequently be washed away down the drain. The softener at the Exhibition is 4ft. 6in. in diameter, and comprises an electrically welded vessel equipped with all the necessary pipes, valves, and fittings, with a special system of collecting pipes and nozzles. As will be seen from the section, the bed of Kenzelite is supported on layers of fine and coarse gravel which, together with the collecting nozzles, ensure an even distribution of the flow throughout the drum.

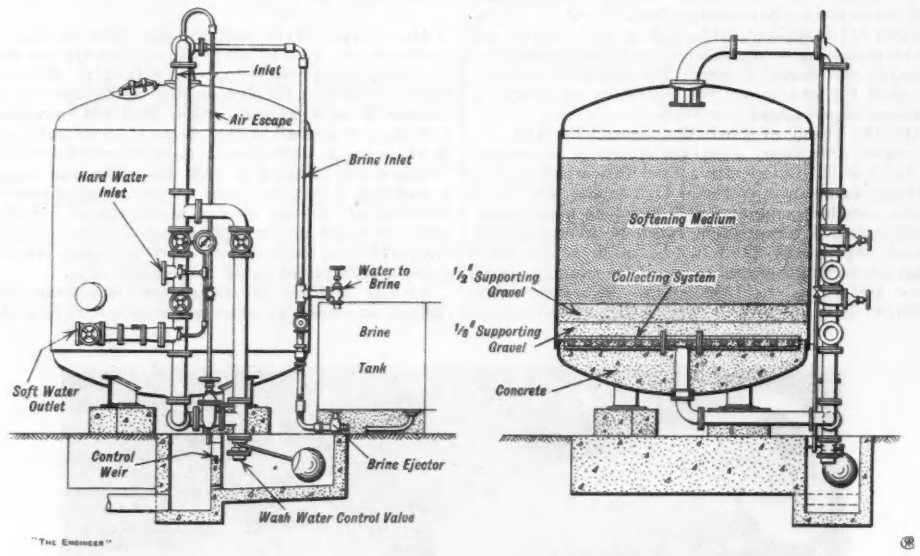


FIG. 5—WATER SOFTENING PLANT—KENNICOTT

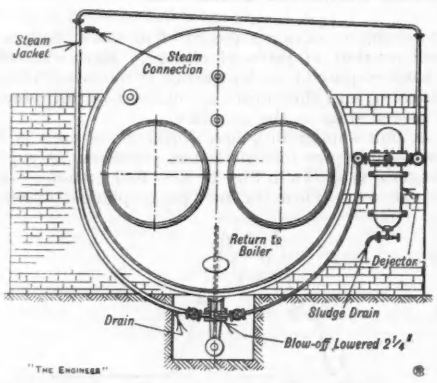


FIG. 6—"DEJECTOR" ARRANGEMENT—KENNICOTT

The Dejector—see Fig. 6—is intended for boiler plants where the capital expenditure on a large softening plant is not justified, and is guaranteed to keep the boiler free from scale and sludge. It takes the form of a vessel capable of withstanding the full boiler pressure mounted in any convenient position beside the boiler, and connected with the water space by two pipes. It is generally most convenient to make these connections by lowering the usual blow-down bend and inserting a thick flange as shown in Fig. 6. This flange is drilled radially for the connections, and one of them is carried up inside the boiler by a riser. The pipe from the other branch to the Dejector is covered with a steam jacket to keep it warm, while the return pipe is allowed to cool. As a consequence, there is a constant circulation of water through the Dejector in which precipitated solids and hardening salts are arrested to be discharged to the drain at convenient intervals. A controlled dosage of soda ash solution is added to the water as it returns to the boiler. A testing set is provided and tests are made periodically to ascertain the alkalinity of the water in the boiler, and according to this result the soda control valve is adjusted so that the water in the boiler is maintained between the minimum and maximum range.

F. J. EDWARDS, LTD.

As at previous Exhibitions at Olympia, F. J. Edwards, Ltd., of 359–361, Euston-road, London, N.W.1, has a comprehensive display of sheet metal working machines and tools, many of which are familiar to our readers. The power press which we illustrate in Fig. 7 is, however, new. This machine, it will be seen, is of the double-sided type, and has a frame strengthened and widened to accommodate a double slide guide attached to the connecting-rod, which ensures freedom from side thrust. It has its own motor and may be driven either by toothed gearing, as shown, or by a belt. Another new press on exhibit is of the open front type with an adjustable stroke. It has phosphor bronze bearings, a positive brake and ample height for the tools. There is a safety clutch locking device for use while the tools are being set. The table has a large area and the machine is fitted with an inclining mechanism.

Other machines which are to be seen on this stand include guillotine shearing machines, a 6ft. by 14 gauge high-speed power guillotine which is being demonstrated, throatless and irregular shape shearing machines, and a universal shearing machine under power, with a capacity of 14 gauge and a 30in. throat, which is suitable for irregular cutting and interior work. No holes require to be drilled. There are circle cutters with a quick and easy adjustment for various diameters, bending rollers of the ordinary and slip roll type, cone rolling machines, and a folding machine for ordinary edging work and universal machines for box and trunk making of the swing beam type.

Punching and shearing machines are shown under power for mitreing, square cutting 5in. by 5in. by ½in. angles, notching, shearing plates, bars, squares and punching holes 1in. diameter through ⅝in. thick metal. They are of steel construction, and have a self-contained motor. Hand and fly presses, and foot lever presses; grooving machines for closing the side seams on box and pipe work; a wheeling and raising machine with a quick release drive to the bottom roller, having 42in. throat clearance for motor body and panel work.

A comprehensive selection of swaging and beading machines includes a heavy universal motor-driven machine for handling sheet metal up to 14 gauge thick; jennies or burring machines, hand operated, are shown in all sizes, and wiring machines, hand operated, with five pairs of rollers, for wiring the edges of straight, curved, or cylindrical work; a hand lever angle-bending machine, with detachable dies for box work, &c.; a bar-bending machine, a treadle-operated notching machine, and a hand-operated open-ended angle iron rolling machine for bending angle iron, tee iron, and other sections up to 1½in. by ½in. section. There is also a large selection of small tools, such as snips, panel heads, hammers, punches, soldering irons, and stoves, &c.

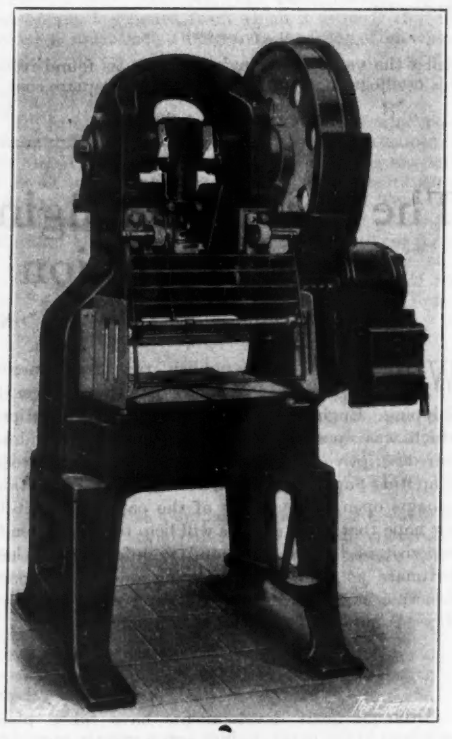


FIG. 7—DOUBLE-SIDED POWER PRESS—EDWARDS

THE TURBINE FURNACE COMPANY, LTD.

Besides the Lancashire boiler front which comprises the stand front of the Turbine Furnace Company, Ltd., 238B, Gray's Inn-road, London, W.C.1, the company shows a new form of grate for comparatively small boilers, sections through which are given in Fig. 8.

In the case of the boiler front the two furnaces are equipped differently, the one on the left for machine firing by means of a sprinkler stoker and fan-forced draught, and the other, on the right, with a standard Turbine furnace with steam-jet-forced draught. In this case there is an extension at the back of the grate on to which the fire can be piled, during clinkering operations, and then drawn back again over the bars. This system of working is claimed to be much more convenient than the usual half-and-half method, and is an efficient smoke preventer. These furnaces will burn practically any fuel, including sawdust and "coal" containing 30 per cent. of ash. The steam consumption of the draught jets is said to be equivalent to 2 h.p. for a 9000 lb. boiler.

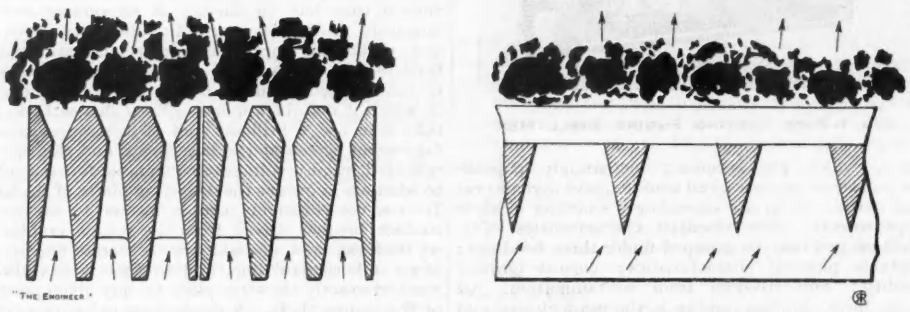


FIG. 8—SECTIONS THROUGH GRATE FOR SMALL BOILERS—TURBINE FURNACE

The Turven bar shown in Fig. 8 has, it will be seen, air spaces somewhat after the fashion of a Venturi

tube which, it is said, turns velocity into pressure, and, instead of leaving the draught to chance provides the correct proportion of air at sufficient velocity and pressure to give a high thermal efficiency—an efficiency of 80 per cent. is claimed. The fuel is held clear of the air spaces, and on account of the humidity provided with the air for combustion, clinker will not cling to the bars.

THE MOLLART ENGINEERING COMPANY.

Visitors to the Exhibition will find much to interest them in the design of the universal joint exhibited by the Mollart Engineering Company, of Thames Ditton, Surrey. This joint, the construction of which is shown in Fig. 9, was originally devised by A. J. Mollart and J. C. Hendra, of the firm mentioned, to meet certain difficulties that had been encountered in the drive to the rotor head of autogiros. But its sphere of application is far wider, obviously, than the field for which it was at first designed. As will be inferred from the engraving, it is of the ball and claw type. The ball which may be from ½in. to 2½in. diameter, and is made of 32 ton tensile steel, is formed with two grooves at right angles to one another on its surface. In each of these grooves ride the tongues of two fork members, which engage the ball, jointly, over an angle of about 250 deg. The parts of each pair of fork members are located together by tenon and groove, as shown in the drawing, and held in contact with one another and the ball by an enclosing

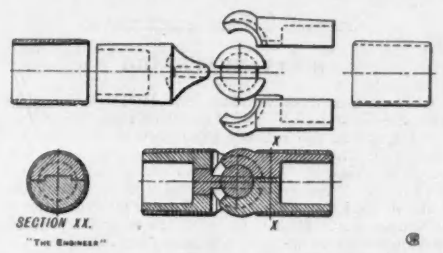


FIG. 9—UNIVERSAL JOINT—MOLLART

sleeve, which is pinned into position. The bore of the sleeve is usually slightly tapered, as also are the shanks of the fork members. For attachment to shafts the ends of the shanks are bored and can be threaded or splined or drilled for taper pins. The grooves in the ball and the tongues on the forks are hardened and ground, and oil channels are arranged to feed the lubricant properly over the sliding surfaces. Drives can be transmitted through a maximum angle of 42½ deg., and owing to the large arc of encirclement of the forks around the ball, the joint is capable of withstanding quite heavy stresses in tension as well as compression.

A specimen joint with a 1⅜in. diameter ball was submitted for test to the National Physical Laboratory and the resulting report was of a very satisfactory nature. Under static torque test a maximum torque of 16,100 lb.-inch was recorded at fracture, which occurred at the fingers and ball, and at the elastic limit the torque was 7160 lb.-inch. Under the working test at speeds from about 300 to 1240 r.p.m. at 5 deg. inclination, efficiencies of 95 per cent. were shown, and a maximum horse-power of 8·5 was transmitted at a temperature of 74·5 deg. Cent. At 4 deg. inclination 10·5 h.p. was transmitted at 103 deg. Cent. and 96 per cent. efficiency.

(To be continued.)

South African Engineering Notes.

(By our South African Correspondent.)

CAPE TOWN, August 15th.

New Ships for South African Route.

THE great expansion which has taken place in the overseas trade of the Union of South Africa in the 2½ years since the country went off the gold standard has furnished shipbuilding yards with a great number of orders. In the last eighteen months up to June 30th, over sixty vessels, additional to those already plying, have been placed on the South African trade routes, among them some new and some reconditioned and enlarged ships. During July two American and two British lines have entered the trade and will have, between them, some eight to ten ships running here. In addition, twenty-eight new ships are being built or about to be laid down by various lines to compete for this trade, and practically all faster than others of their classes at present in service. They range in size from the 25,000-ton mailships for the Union-Castle Line down to one of 3600 tons. The following is a list of these new ships:—Two 25,000-ton mailships for the Union-Castle Line; two 16,000-ton liners for the German African Lines; two 15,000 intermediates for the Union-Castle Line; three 10,800-ton refrigerated ships for the Blue Star Line; two 8800-ton liners for the Bullard-King Line; two 7800-ton cargo boats for the Wilhelmsen Line; one 7000-ton steamer for the Clan Line; one 7000-ton steamer for the Shire Line; two 6300-ton cargo boats for the Osaka Shosen Kaisha; one 6200-ton cargo steamer for the T. and J. Harrison Line; one 3700-ton cargo boat for the Hogarth Line; one 3600 refrigerated liner for the Swedish Transatlantic Line, and the list is completed by one 2000-ton dredger and two 600-ton tugs for the Union Government, two 300-ton trawlers for a new Cape company, and three 250-ton whalers for Messrs. Irvin and Johnson. The total gross tonnage exceeds 200,000 tons. Orders for additional vessels, including several liners, are expected to be placed in the near future by other companies, which are now making inquiries from shipbuilders. Some of them will fly foreign flags. Whether competition is or is not being overdone remains to be seen, but present opinion is that it is being overdone.

Developing Union Harbours.

Apart from the provision of more dock accommodation to cope with the increasing number and size of ships carrying the Union's growing exports and imports, other equipment is being augmented. Day and night shifts are working at full pressure on the construction of the harbour precooling plant for the citrus export industry at Port Elizabeth. This season the port is still using the old system of refrigerator lighters, the fruit, on arrival from up-country, being placed in lighters before being transferred to ships at the quayside. By next season the new plant, which consists of refrigerator chambers built into one of the quays below high-water mark, will be ready for use, and Port Elizabeth will be in a position to handle an even larger proportion of the Union citrus crop than at present. As far as it is possible to ascertain, Port Elizabeth will be the only port in the world with precooling chambers for fruit actually built into a quay. They will be able to accommodate some 4000 tons, or just on 70,000 cases of fruit at a time, and they are being constructed so as to enable the fruit to be lifted by cranes direct from the cooling chambers into the ships' insulated holds. Tenders have recently been invited by the South African Railways Administration for the supply and delivery of two new steam tugs for use at Cape Town and Durban. The new tugs will each have a length of 145ft., breadth of 33ft., and moulded depth of 16ft. to 17ft. They will be fitted with steel twin screws suitable for sea and dock work, and generally will be built in accordance with the best shipbuilding practice. The engines will consist of two sets of the inverted three-cylinder, triple-expansion, surface-condensing type, giving a total indicated horse-power of approximately 2500 for each tug. The tugs will be required to work in confined waters, manœuvring the largest types of ocean-going vessels visiting South African ports. Both will be fitted with modern fire and salvage appliances, wireless telephone/telegraph, and direction-finding equipment. Work has been begun in the Durban railway workshops on a big programme of saloon and truck construction, including fifteen first and second-class main line saloons of the latest type at a cost of £63,000; two hundred four-wheeled covered goods trucks, costing £70,000, and one hundred four-wheeled fruit trucks, at a cost of £37,000. Later on a start will be made on another one hundred fruit trucks, but of slightly different design, costing a similar amount. A special effort is being made to put the main line saloons into traffic in time for the Christmas holidays.

A Floating Block Layer.

In order to expedite the construction of the deep-water berth in the new dock at Cape Town, Mr. J. F. Craig, the Harbour Advisory Engineer of the Union, fitted out early this year the old dredger "Labrus" as a floating block layer, and it is claimed that it is the first time quay construction work on such a large scale has been attempted from a floating platform. The idea was evolved by Mr. Craig as the only way in which the work could be completed in the required time. If this new berth is completed by February, 1937, as expected, it will be a South African harbour-building record. Since the first block was laid seven weeks ago, over 600 blocks, containing 9000 tons of concrete, have been placed in position. At one part the divers are working in 64ft. of water. Part of the quay wall is now only 13ft. beneath the surface.

Important Ship-repair Job.

The Danish motor ship "Australien," 6652 tons, recently sailed from Cape Town after having been twenty-five days in port for engine repairs. The "Australien" broke a crankshaft on her voyage from Copenhagen to Melbourne, and limped into Table Bay on one engine. The repair work included the fitting of a new crankshaft, remetalling bearings, and minor repairs to the engine, and is believed to be the biggest job of its kind tackled at Cape Town.

Wireless Direction-Finder.

It has been proved at inquiries into the loss of vessels on the South African coast that had there been a direction-finding station ashore many would have been saved. A wireless direction-finder, the whole apparatus weighing nearly a ton, has now been erected in the new look-out station, placed on the grain elevator at the Cape Town docks. Besides the direction-finder, the set incorporates wireless telephony, by which a ship can be conversed with when up to 50 miles from the port. Ordinary Morse messages can also be transmitted through the new apparatus, which has a range under average conditions of about 100 miles. It has happened before now that a ship has suddenly found itself steaming for the rocks somewhere down the Cape Peninsula's coast when her officers thought they were safely inside the bay. Such mistakes can now be avoided, for the direction-finder will send out intermittent signals which, when picked up by the direction-finder of an incoming ship, will show at once her bearing from the shore station. This direction-finder now erected at Cape Town is the only one on the coast, but the tests which have been carried out since it was "calibrated" have been so satisfactory that the equipment of Durban and Port Elizabeth may follow.

Beach Erosion Prevention.

Mr. G. P. Nijhoff, the Dutch harbour authority, who was head of the Commission invited by the Union Government to investigate and report on the extensions at Cape Town Harbour, and who was mainly responsible for the Report and the recommendations made in it, has arrived in Durban to investigate the problem of preventing the erosion of the Durban foreshore. His report will not be completed for five or six months. Since his departure for the Far East, where he had been invited to investigate and report upon certain harbour problems, Mr. Nijhoff had, he stated, been out of touch with harbour affairs in the Union, and did not know that the work in hand at Cape Town differed entirely from the recommendations of the Harbour Commission. With regard to Durban Harbour, he stated it was very essential that something should be done promptly.

Electric Locomotives Ordered.

A British engineering firm—Metropolitan-Vickers—has secured the contract for the supply of twenty electric locomotive units for the South African Railways and Harbours Administration, the total value of the order being nearly £250,000. I learn that tenders were received from many other firms. The units which have now been ordered are destined for the Natal Railway System, and will be used on all electrified portions of that system, including the Glencoe-Volksrust and the Cato Ridge-Durban sections. Recently five electric units were purchased from the same firm, bringing the total number of additional units available up to twenty-five. A start has been made on the electrification of the main line between Glencoe and Volksrust. The masts are being made of old steel rails, and are being erected on the first 10 miles of the 75 to be electrified. The electrification work, which will be carried on at the same time as the straightening of the line and the elimination of curves—a scheme which will cost a quarter of a million pounds—will, it is anticipated, be completed by the end of next year. The section between Durban and Cato Ridge will be finished about nine months earlier, so that Natal will have an all-electric main line from the port of Durban to the border by the beginning of 1937. When the whole route is electrified it is anticipated that trains will reach Durban from Johannesburg and *vice versâ* practically overnight.

Flying-boat Service, London to Cape.

Negotiations are stated to have been concluded to the satisfaction of the Imperial and Union Governments for the establishment of a bi-weekly flying-boat service between South Africa and London. It is further stated that the amount of subsidy to be paid by the Union Government has been settled, and it is believed that it is to be an annual sum of £122,000. Subject to the approval of the British Cabinet, the agreement will endure for from twelve to fifteen years. This subsidy is to be made up as follows:—£52,000 for carrying mail matter, £30,000 contributed by the South African Railway Administration, £20,000 contributed from postal revenue, and £20,000 taken from the general revenue. The overland service of Imperial Airways will be discontinued and the flying-boat service will operate from London to Alexandria, Khartoum, on the Nile, to Kissimu, on the Great Lakes, across to Kilindine and down to Durban, which will be the terminus. An overland branch service will probably be operated from Nairobi to Lusaka, the capital of Northern Rhodesia. When the new service comes into operation, probably towards the end of 1937, the flying boats will cover the distance from London to Durban in 4½ days, operating day and night, and all overseas first-class mail will be distributed from Durban. What type of craft will be used is still uncertain. There is a possibility that they may be amphibians over some sections of the route. That they will have a much greater carrying capacity and speed than the present types is certain.

Imperial Airways Service.

The Imperial Airways contract with the Union Government expires in January, 1937. Negotiations are at present being conducted with the British Government in regard to future developments in air services between the Union and Great Britain. It is understood that any future air contracts will be made on a strictly business basis, and that the Union Government will require a service which will closely co-operate with the Union's internal air service. There is no doubt that Imperial Airways will meet keen competition from foreign lines to secure the new contracts. Imperial Airways, however, has secured the confidence of the public by reason of its excellent service, and it is expected that with its experience gained in the last few years of flying conditions in Africa it will be in a favourable position for the renewal of the contract. On the other hand, there is the fact that Junkers planes have ousted British from the South African Airways service, and that the Minister of Aviation is much impressed by the satisfactory manner in which these Junker planes have operated, so that a German company, offering a service with these aircraft, would be well in the running.

Crane Tenders.

Tenders for a 60-ton steam travelling break-down crane are being called for by the South African Railways and Harbours Administration. United Kingdom firms, and others, are being invited to tender. Tenders are also being invited for a 36-ton steam travelling break-down crane.

22-ton Anvil Base.

The casting of an anvil base weighing 22 tons was completed on July 26th in the Durban Railway Workshops. It is claimed to be the biggest casting ever made in South Africa, and is intended for the Salt River Railway Workshops, where it will be used with a 3-ton hammer. Two cupolas were used to melt the metal, and a section of the factory roof had to be removed to enable the crane to lift the casting. After it had been cooling eight days, it was railed to Cape Town. The anvil, which itself weighs 14½ tons, was similarly cast and machined in the Durban shops and then sent to Cape Town.

Electrical Extensions at Bloemfontein.

The Town Council of Bloemfontein has been authorised by the ratepayers to raise a loan of £328,000. Of this sum, £165,000 will be allocated to electricity extensions. Of the balance, £50,000 is for waterworks,

£21,000 for a new sewage system for the native locations, and £33,000 for a new sewage system for the town.

Rand Shaft-sinking Record.

The world's circular shaft-sinking record was achieved at No. 18 circular shaft of the Crown Mines during July, 390ft. having been sunk during thirty-one days. This is equivalent to an advance of just over 5ft. 4in. per drilling shift. During this period the shaft was bricked for 340ft., occupying twenty shifts. The depth of the shaft at the end of July was 1744ft. It was started on January 30th, 1935. With this record the sinking in the last three months has been no less than 1049ft., of which 934ft. have been walled, an outstanding achievement. The previous record in circular shaft sinking was established at the Randfontein Estates in 1926, when the ventilating shaft was sunk 381ft. in thirty-one days with no walling. The diameter of that shaft, concrete lined, was 22ft. The diameter of the Crown Mines shaft, lined with concrete bricks, is 18ft.

Electric Locomotives for the South African Railways.

EARLY in January of this year the Metropolitan-Vickers Electrical Company received an order for five additional electric locomotives for the South African Railways and another order for twenty engines in May. Apart from certain improvements, all these locomotives will be duplicates of the ninety-five supplied by this company during 1923–27. Occasionally the latter are used singly, but more often in units of two or three coupled together and controlled by one driver, and for this reason the new engines have to possess the same characteristics as those now in service. The principal improvements consist of roller bearings instead of sleeve bearings, resilient gear wheels instead of solid wheels, and Timken bearings in place of the plain type for the bogie axle bearings. The new locomotives are also fitted with automatic couplers. The lay-out of the control apparatus in the body is completely rearranged in accordance with the Metropolitan-Vickers Company's later experience, and is more accessible for inspection, cleaning, and maintenance. Except where the improved lay-out demands changes, the contactor apparatus and allied equipment are unaltered.

In spite of the changes necessitated by the improvements, any of the new locomotives will not only be capable of running in multiple unit with any of the original locomotives, but the bogies and bodies will also be freely interchangeable. The weight of each unit in working order is about 67 long tons. The main power equipment of each locomotive consists of two pairs of traction motors. Series-parallel control of the motors, field control, and reversing are obtained by means of electro-pneumatic unit switches and switch groups. Four economical speeds are obtainable and regenerative braking is provided for.

The body containing the electrical equipment and the auxiliary gear is supported by two four-wheel bogie trucks coupled together by an articulating joint that prevents transverse movement between the adjoining ends of the trucks, but allows a small amount of vertical lift of these ends relative to one another. Complete freedom of angular movement of the trucks in either a horizontal or vertical direction is thus obtained. The life of the tires is prolonged by the prevention of transverse movement, and although this causes a certain amount of lateral stress on the rails when entering a curve, wear on the wheel flanges is reduced to a minimum.

The buffing and draw gear, which is of the central type, is mounted directly on the bogie trucks. The bogie centre pivots are made in three castings, the top one of steel being rigidly bolted to the underframe and having a spherical seating which rests in a phosphor-bronze rubbing plate which is held by a steel casting bolted to the bogie centre soleplates.

The trucks are of plate frame construction, arranged with top and bottom stay plates at the ends and centre. Besides acting as a support to the bogie centre castings, the transom carries the motor nose suspension brackets. The bearing springs are of laminated pattern with adjustable links, and are placed above each axle-box. Beams pivoted on knife edges, which are in turn attached to the centres of the bogie frame plates, provide for compensation.

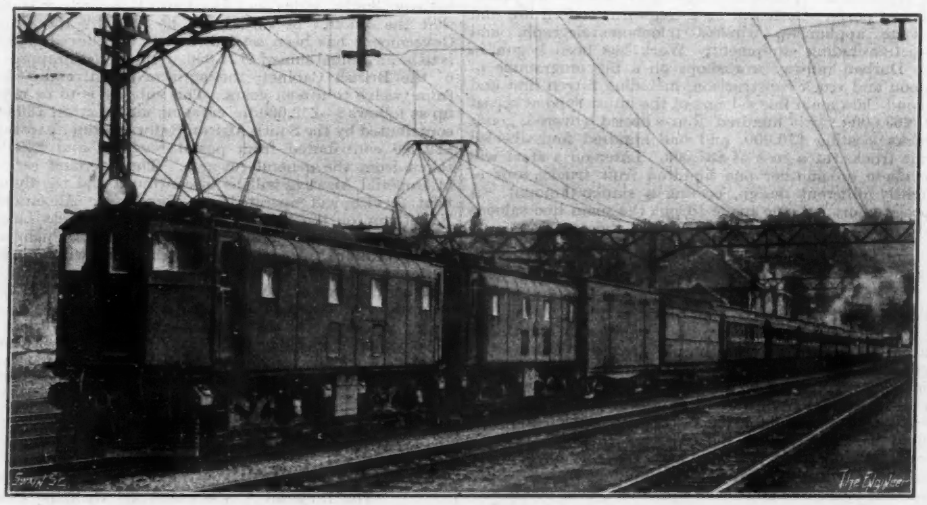
The body of the locomotive is divided into five compartments, consisting of a driving cab at each end, two auxiliary machinery compartments adjoining these, and a high-tension chamber in the centre of the body. Each driving cab contains all the control gear, meters, gauges, brake valves, &c., necessary for control. The two cabs are connected by a corridor running along one side. The central high-tension chamber, containing all the high-voltage control gear and resistances in special compartments, is accessible from the corridor by a sliding door, which is both mechanically and electrically interlocked to prevent its being opened while the apparatus is alive.

The machinery compartments between the central high-tension chamber and the driving cabs contain two motor generator sets, one of 16-kW capacity and the other of 28 kW, each with a blower fan on its shaft for ventilating the main motors. In addition, there is one compressor, one exhauster, air reservoirs for the brakes, low-tension control apparatus for the auxiliaries and battery, together with contactor gear for controlling the field of the 28-kW motor generator. The battery is mounted in cases hung underneath the locomotive body. Sections of the roof above the auxiliary machinery compartments and the high-tension chamber are easily removable to enable heavy parts to be lifted out for repair.

The main driving series-wound motors are of the axle-mounted type. They are designed to work at 1500 volts and are permanently connected, two in series, across the 3000-volt trolley line. Each motor has a rated output of about 300 h.p. at 1350 volts, which corresponds to the average line pressure. The corresponding horse-power at full line voltage (1500 volts per motor) is about 340 h.p. The continuous rating of the motor at 1500 volts with full field and forced ventilation is 225 h.p. at the rim of the driving wheel, with a temperature rise not exceeding 80 deg. Cent. A tapping is provided on the series field so that two economical speeds are available for any combination of motors.

The locomotive brakes are designed for operation by compressed air, but as vacuum brakes are standard on South African rolling stock, each locomotive is equipped with an exhauster driven by a 100-volt motor. Each unit is fitted with two pneumatically controlled current collectors, compressed air being led to the cylinders through an electrically operated valve controlled by a two-way switch in the driving cab. The control wires run through the train line control bundle, and consequently the pantographs of several coupled locomotives can be operated from one driving cab.

The accompanying illustration shows two Metrovick locomotives, each of 1200 h.p., hauling a passenger mail train on the South African Railways.



1200 H.P. ELECTRIC LOCOMOTIVE AND TRAIN IN SOUTH AFRICA

The Tawa Flat Deviation, New Zealand.

IN June, 1933, the New Zealand Government decided to undertake the construction of a new central station, costing £339,000, and numerous allied works at Wellington, the capital city and principal port. This decision ensured the efficient utilisation of the double-track deviation to Tawa Flat and of the electrification of the line between Wellington and Paekakariki. Paekakariki is the last station in the suburban area. It is at present 27 miles out, but this distance will be reduced to 24½ miles by this deviation, which has been under construction for some time and has recently been brought into use, single-line working, for goods traffic.

The Tawa Flat deviation constitutes a 7½-mile stretch of double track. It is a fine example of modern railway engineering and, when complete, will reduce the length of the main trunk line between Wellington and Auckland by 2½ miles. The principal engineering features on it are two tunnels, one ¾ mile in length and one 2¾ miles in length. Its steepest gradients are 1 in 110 in the tunnels and 1 in 100 (compensated) in the open, as compared with a steepest section of 1 in 36 on the existing route. Up to March 31st, 1935, the expenditure on the deviation was £1,359,246, and to complete the formation and track work a further sum of £60,754 will be required. The total cost of the work will therefore be £1,420,000. After careful investigation it was decided to adopt electrification for the section between Wellington and Paekakariki. A consideration which influenced this decision was the desirability of obviating the smoke nuisance when traversing the long tunnels on the deviation. The estimated cost of this electrification is £277,525.

The possibility of working the Tawa Flat deviation with the existing Wellington station yard lay-out was carefully investigated and was found to be quite impracticable. It was therefore necessary to remodel the yard, buildings, and lay-out generally with a view to obtaining a return on the capital already spent on the deviation. These yards involve the provision of 15 miles of sidings, but the yard has been so designed that only the minimum number of sidings required for handling the present traffic need be provided immediately, further extensions being laid as required. An area of about 68 acres was reclaimed from the sea to permit of a permanent station yard being constructed to combine the two station yards at Lambton and Thorndon and make provision for reasonable future expansion. The cost of this land reclamation including a sea wall on the harbour frontage was £494,629. In the meantime it was found necessary to provide new facilities for handling goods traffic, and a new goods shed and loading sidings were provided as part of the scheme for the permanent lay-out. The total amount spent up to March 31st, 1935, on the new yard and buildings is £291,845, making the total cost to that date £786,474.

The new station building is of interest in being fireproof and earthquake-proof throughout, the foundations, composed of steel columns encased in concrete, are extended through the reclamation land to below the original harbour bed. The five upper floors are supported by steel beams between these columns. The interior partitions are of terra-cotta, while the external walls are of reinforced brickwork. The bricks are made with slots, enabling vertical steel bars to be passed through them and secured to the beams above and below. The design of the structure was undertaken by the Departmental Structural Engineer, who made tests and investigations in Japan as to the value of this type of construction. The floors are of concrete and all doors, &c., are of fireproof material.

SIXTY YEARS AGO.

ALTHOUGH no lives were lost when H.M.S. "Vanguard" was rammed and sunk by H.M.S. "Iron Duke" on September 1st, 1875, the mishap gave rise to a considerable amount of discussion and controversy. It happened in fog off the coast of Wicklow. The two vessels were sister ships of the "Audacious" class and were twin-screw iron-clads of 6034 tons carrying fourteen guns and protected by 6in. armour. Their bows were formed with a projecting peak intended to be used for ramming an enemy. The peak of the "Iron Duke" caught the "Vanguard" close to one of the engine-room bulkheads. The rent apparently was not very extensive but the water found its way into other compartments and the crippled ship sank in about three-quarters of an hour. In a leading article in our issue of September 10th, 1875, we employed the occasion to throw strong doubts on the practicability of ramming as an effective method of attack. Ramming had it was true been employed at the battle of Lissa between the Italians and the Austrians, but we argued that while it might in special circumstances be used with disastrous effects it was ridiculous to contend that fighting ships of the future would rely upon it as the principal method of attacking an enemy. It was, we thought, most unlikely that a skilful captain would ever allow his ship to be manœuvred into the only relative position in which a successful ramming attack could be carried out against her, namely broadside on to the enemy's bows. With good manœuvring powers a well-handled ship moving at a moderate speed could, there was little doubt, avoid being dangerously injured by ramming. It was equally doubtful whether the enemy would be inclined to resort to ramming as a normal method of attack, for if he missed his mark he would expose his broadside to the fire of the attacked vessel. In any event the possibility of ramming implied the fighting of an action at close range. The advent of the 81-ton gun had rendered the old "long bowls" game quite practicable once more and except in a very rough sea it was improbable that actions would be fought at a range much less than a mile. Other less general points for discussion subsequently arose out of the accident. In a later issue we find it stated that the "Vanguard" and her sisters were notoriously weak in their construction. Their structure, it was said, was damaged when they were launched and, later, when they stranded accidentally. The "Vanguard," further, was a crank ship. On her trials in 1870 she heeled dangerously to 17 deg. in a good breeze although no sails were spread. To improve her stability her double-bottom compartments had been filled after her trials with bricks and cement. At the court-martial of her officers which followed her loss censure was expressed upon them. They made no attempt to stop the leak or tow the ship into shallow water. They acted bravely in saving the crew but so far as saving the ship was concerned they showed no intelligent perception of the possibilities which would have suggested themselves to men possessing a very moderate degree of engineering ability. It might be said, we wrote in a subsequent issue, that captains and officers were not necessarily engineers. To such an assertion it could be replied that the use of steam machinery was leaving us without sailors.

PURCHASE of streamline trains in the U.S.A. is expected to be stimulated as the result of a formula worked out by the Reconstruction Finance Corporation under which it will aid in financing manufacturers of such trains, says *Iron Age*. The R.F.C. has announced that it will make loans to manufacturers up to 80 per cent. of the cost of construction. The loans will be made under the specific provisions that the R.F.C. first will have to approve leasing of a train to a given railway, and the design and construction of the train must be acceptable to the Government lending agency. No limit has been set on the total loan or the number of trains, the plan being available to any responsible manufacture. The estimated cost of each train is reported to be about 250,000 dollars. Under the scheme trains would be leased by manufacturers to railways, following approval of the R.F.C., which will take mortgages from manufacturers and liens on the railways. Payment of the trains will be made under an amortisation plan over a period of years.

Rail and Road.

THE question of running a bus service through the Mersey Tunnel, a subject of keen controversy on Merseyside, has been settled in an expert report on the practicability of the scheme, which has been submitted to the Joint Tunnel Committee. The report states that a bus service through the tunnel is not an economic proposition.

A NEW express locomotive, "No. 6170," which is to be built this autumn at Crewe, will be named "The British Legion." The engine will be of the "Royal Scot" class, but will have a tapered boiler and thus be different from the "Silver Jubilee" class. "The British Legion" will be the first engine of the "Royal Scot" class to be built at Crewe, the previous seventy having been constructed by the North British Locomotive Company or at the L.M.S. Derby Works.

THE Minister of Transport has made regulations prescribing the form which direction indicators and stop lights on motor vehicles must take if they are fitted. The object of the regulations is to secure that all direction indicators and stop lights fitted to new motor vehicles after January 1st next shall be similar as regards type and position on the vehicle. The regulations will not affect existing vehicles, nor will they make the fitting of direction indicators or stop lights compulsory.

THE annual report for the year 1933–34 of the Indian Railway Board shows that during the year twenty-one passengers and nine servants were killed in train accidents as compared with six passengers and eight servants killed during the previous twelve months. The increase in the passenger fatalities was, we anticipate, due to seventeen lives being lost when the rear portion of a mixed train broke loose on the Mysore Railway on July 11th, 1933, and ran back and collided with the mail.

WHEN the winter train services are brought into use on September 30th, some of the L.M.S. London-Birmingham trains which are now timed to do the journey in two hours will have the timing reduced by five minutes. On the L.N.E.R. the West Riding Pullman will be renamed the "Yorkshire Pullman," and will terminate at Harrogate, and not, as now, run on to Newcastle. A change of importance to business men is that the 5.30 p.m. Kings Cross to Newcastle will be combined with the 5.45 p.m. to Hull.

A SLIP of memory, when writing the note on the new Railway Employment Officer for the Ministry of Transport that appeared herein on September 6th, made us say that Mr. Walter Hudson was one of the sub-inspecting officers appointed in 1894. We have since remembered that we should have said Mr. J. J. Hornby; the remark as to membership in the Associated Society of Railway Servants, however, stands. The mistake arose from the fact that Mr. Hudson was, like Mr. Hornby, on the North-Eastern Railway, and that he was a member of the Royal Commission of 1899, which inquired into accidents to railway servants.

THE Ministry of Transport railway statistics for May have now been published. It is stated that the incidence of Whit Monday having occurred in May in 1934 and in June in the present year was counterbalanced by the increased traffic in May last owing to the celebrations of the Silver Jubilee. The number of passenger journeys, when compared with those of the corresponding period of 1934, showed an increase of 6·5 per cent., but the receipts fell by 4·3 per cent. Freight increased by 3·0 per cent. in tonnage, and by 6·7 per cent. in receipts. The freight train mileage rose by 2·0 per cent., the average train load from 120 to 122¾ tons, and the net ton-miles per engine-hour from 456¼ to 466¼.

WE regret to hear of the death on August 25th of Mr. G. P. Wainwright, who used frequently to be met in locomotive circles, where he was very popular and where his cheerful spirit, despite a handicap from lameness, was much admired. Mr. Wainwright was the son of Mr. W. Wainwright, the carriage superintendent of the South-Eastern Railway, and was the brother of Mr. Harry S. Wainwright, the S.E. and C. locomotive and carriage superintendent. He, too, was on the South-Eastern and then on the Midland, becoming some thirty odd years ago the London representative of Messrs. George Turton, Platts and Co., from which position he had, owing to ill-health, to retire seven years ago.

THE Bristol and Gloucestershire Railway Company, which was one of the five corporate bodies which initiated the Great Western Railway, owned a line of 5ft. gauge, worked by horses, from the harbour at Bristol, through Mangolsfield, to Coalpit Heath, a distance of 9 miles. This line was authorised by 9 Geo. IV C. 93 of 1828, and opened on August 6th, 1835—just before the Great Western Bill received the Royal Assent. In 1838 the name was altered to the Bristol and Gloucester, and its extension northwards to Standish was sanctioned. At that point it was to join a line from Swindon to Cheltenham; a connection at the southern end so as to obtain an entrance into Temple Meads Station was part of the scheme. Meanwhile, the Birmingham and Gloucester was being constructed. It was to join the Cheltenham line at Lansdown Junction, Cheltenham, slightly south of the Great Western station, and to have its own station, also on the north side of the junction. The line between Lansdown Junction and Gloucester was to be jointly owned, and that probably was the first jointly owned railway in this country. The Bristol and Standish line had been altered to broad gauge in order to suit that of the line from Swindon, and the Great Western hoped to acquire it, but the Midland, which had obtained the Birmingham and Gloucester, made a better offer. By constructing a standard gauge line of its own from Gloucester to Standish and making the remainder to Bristol of mixed gauge, the Midland obtained definite access into Bristol, and the first standard gauge passenger train arrived there on May 29th, 1854. As owners of the original Bristol and Gloucestershire line, the Midland became part proprietors of what is now Bristol Joint Station, and that condition prevails to-day. Further, as that line was opened two years before the Leicester and Swannington, it was the oldest section of the Midland Railway.

Miscellanea.

THE Ulster Tourist Trophy Race on Saturday last was won by Mr. F. W. Dixon, driving a Riley at an average speed of 76·90 m.p.h.

IN France, 7 million pounds are to be spent on special motor roads, giving employment to some 15,000 men at present unemployed.

A TRANSPORT BOARD, consisting of seven members, has been appointed to take over the control of all the road transport services in Northern Ireland.

AN association called the Instituo de la Metalurgia y de la Mecanica has been formed in Barcelona with the object of fixing standards to apply throughout Spain.

A NEW world's land speed record has been set up by Sir Malcolm Campbell, who recently attained a speed of 301·129 miles an hour at Bonneville Salt Flats, Utah.

THE world's twenty-four-hour motor record has been regained for America by Mr. A. B. Jenkins, who travelled at an average speed of 135·47 miles an hour for the twenty-four hours.

THE Rand Water Board has placed contracts to the total value of some £530,246 with British firms. The contracts were secured in spite of competition from several Continental countries.

To further the use of olive oil for lubricating purposes in internal combustion engines, the Algerian Government has established a standard to which the oil must comply. Oil to this standard will be in containers with the official stamp "Algeria" and will be guaranteed in regard to quality.

THE Devon County Council has invited tenders for the construction of the last 2½ miles of the Exeter by-pass road. This by-pass, which, when finished, will have a length of 5 miles, was estimated to cost £220,000, and involves the construction of three new bridges and the reconstruction of two others.

A SOUTHPORT surveyor, Mr. H. Rowe Stevens, has suggested that to link up the coastlines of Southport and Blackpool, a tunnel having twin tubes—one for a railway and another for vehicular traffic—should be driven under the river Ribble. In event of the scheme becoming operative, it would mean that the travelling distance between Southport and Blackpool would be reduced by some 20 miles.

IT is understood that the Government of India intends to reconstruct the Quetta military station at an estimated cost of £7,500,000. The buildings will be erected on a site adjacent to the old site, and one that will avoid the valley line which felt the worst effects of the recent earthquake. It is also planned to erect buildings which, it is believed, will be proof against destruction by earthquake. Work will start on April 1st next, and is to be completed within three years.

TESTS made in New York on reinforced brick slabs, consisting of one course of brick laid on metal lath and grouted, showed unusual carrying capacity and low cost for this type of construction. On a 36in. span a load of 1605 lb. per square foot was carried without failure and with only about ¼in. deflection. The cost, including necessary steel beams, which contributed about a third of the total, is stated by *Engineering News-Record* to have been some 29 cents per square foot.

AN extract in the *Iron and Coal Trades Review* says that a copper content up to 3·69 per cent. does not interfere with carburising results if the specimens are machined free from scale. Scaled specimens do not carburise uniformly, probably due to the preferential oxidation of iron and the formation of a layer of copper underneath the scale preventing carburisation at that point. Tests indicate that such layers of copper formed underneath the scale do not retard decarburisation.

A NEW class of synthetic resins known as the "Acronals" has recently appeared on the German market. According to the *Chemical Trade Journal*, these are polymerised vinyl compounds characterised by their clear, colourless appearance, and complete absence of odour. They are also stated to be highly resistant to cold, unaffected by petrol, and to possess a degree of elasticity "comparable to rubber." Acronal is marketed in two forms—Acronal 1, which is a 25 per cent. solution in ethyl acetate; Acronal L 100 and L 200, both of which are aqueous emulsions of the pure polymerised vinyl compounds without any solvent or plasticiser.

THE Official Returns rendered to the Electricity Commissioners show that 1189 million units of electricity were generated by authorised undertakers in Great Britain during August, as compared with the revised figure of 1059 million units in the corresponding month of 1934, representing an increase of 130 million units, or 12·3 per cent. The number of working days in the month was the same as last year. During the first eight months of 1935 up to the end of August the total amount of electricity generated by authorised undertakers was 10,907 million units as compared with the revised figure of 9733 million units for the corresponding period of 1934, representing an increase of 1174 million units, or 12·1 per cent.

ACCORDING to the Berlin correspondent of the *Financial Times*, at a recent conference, Dr. Bentz, head of the Prussian Geological Institute, stated that in oil boring activities, financed with Reich loans, 105 borings had been planned, leading to a total depth of 99,000 m. Of the programme, 73,356 m. had already been bored and 62 borings completed, while 32 were still in progress and 11 in preparation. Borings had disclosed three new production fields—two in Hanover and one in Baden—in addition to the five already being tapped in Germany. Of the two new fields in Hanover, that at Hoheneggelsen-Mölme yielded 800 tons in August, against 69 tons in July, and in that at Fallstein production in August had increased by 343 tons. The oil yielded in the Baden field was of a high quality, containing a large percentage of benzine and lubricating oil. Borings in Westphalia, south of Bentheim, had struck an oil-containing layer of dolomite. Traces of asphalt and oil found in the neighbourhood opened up possibilities of larger oil discoveries in this district.

Air and Water.

WORKING on an eight-year plan, the Berlin Tempelhof aerodrome is to be extended.

OWING to the fact that the new French liner "Ville d'Alger" is fitted out as an auxiliary cruiser, she will carry out firing practice during her trials.

THE commander of the "Viceroy of India," Captain E. J. Thornton, has been appointed commodore of the P. and O. Steam Navigation Company's fleet.

ITALIAN shipbreakers have recently purchased the German Norddeutscher-Lloyd liners "Coblenz," 9449 tons gross; "Saarbrucken," 9429 tons; and the Hamburg-Amerika vessel "General Mitre," 9891 tons gross.

CONSTRUCTION is shortly to be begun on the aircraft carrier "Arc Royal" at Cammell Laird's Birkenhead yard. Much of the hull of this £2,500,000 vessel is to be electrically welded and it is expected that accommodation will be provided for at least sixty aircraft.

THE Air Ministry has announced that five new Royal Air Force squadrons equipped with heavy bombing aircraft are to be formed. Two of the squadrons are to be stationed at Boscombe Down and the others at Mildenhall, Worthy Down, and Upper Heyford.

THE American Navy Department, in accordance with its new programme, has ordered twenty-three new warships, including a 14,000-ton aircraft carrier and a 10,000-ton cruiser. Twelve of the new vessels are to be built in private yards and eleven in the navy yards.

As a result of the cut in shipping subsidies in France it is feared that three shipping services of the Messageries Maritimes may be suspended. It is stated that ten ships will be laid up and the services to Northern Mediterranean ports, Indo-China, and Australia will be stopped unless special steps are taken.

A Swiss airman, Monsieur Schreiber, has succeeded in crossing the Alps by means of a glider. After being towed to a height of 10,500ft. from Thun he ascended to 12,000ft. and, passing over the Simplon Pass at an altitude of 9600ft., glided over Domodossola and Centovalli at 4000ft. and landed at Bellinzona, Canton Tiano.

THE three "Singapore" flying boats which are flying by the 4000-mile "all-red route" to Basra have successfully completed the first stage of their journey to Gibraltar—a distance of some 1070 miles. The other three stages of the flight will be Gibraltar to Malta, 985 miles; Malta to Aboukir, 920 miles, and from Aboukir to Basra, 1070 miles.

FLYING one of the D.H. "Comets," recently purchased by the French Government for experimental flying, the French Transatlantic pilot, Monsieur Mermoz, has flown from Le Bourget to Algiers and back at an average speed of 202 m.p.h. This is one of a series of flights undertaken to determine the value of small fast aeroplanes for carrying mails on main air routes.

ACCORDING to reports from Washington, President Roosevelt has allotted five million dollars from the Relief Fund to start preliminary construction of a channel linking the Atlantic Ocean with the Gulf of Mexico across Florida from Jacksonville to Port Inglis. It is estimated that the canal would bring the eastern seaboard and the Gulf ports closer by 2½ days, besides reducing hurricane hazards.

FOR the eighth week in succession London's shipping has aggregated over 1 million net register tons. During the seven days ended August 30th, 1231 vessels, representing 1,004,148 net register tons, used the Port of London. Of these 495 vessels (691,443 net register tons) were to and from Empire and foreign ports, and 736 vessels (312,705 net register tons) were engaged in coastwise traffic.

DURING recent trials in the Firth of Forth a new motor coastal vessel, "Ocean Coast," built by Henry Robb, Ltd., of Leith, reached a speed of 13·89 knots over the measured mile. This speed will make the new vessel one of the fastest engaged in the British coastal trade. She is 250ft. long, 38ft. beam, and has a moulded depth to the shelter deck of 22ft. 9in. The gross tonnage is 1210 and the deadweight carrying capacity is about 1750 tons. The engines are of the five-cylinder type, developing 1450 b.h.p. at 250 r.p.m.

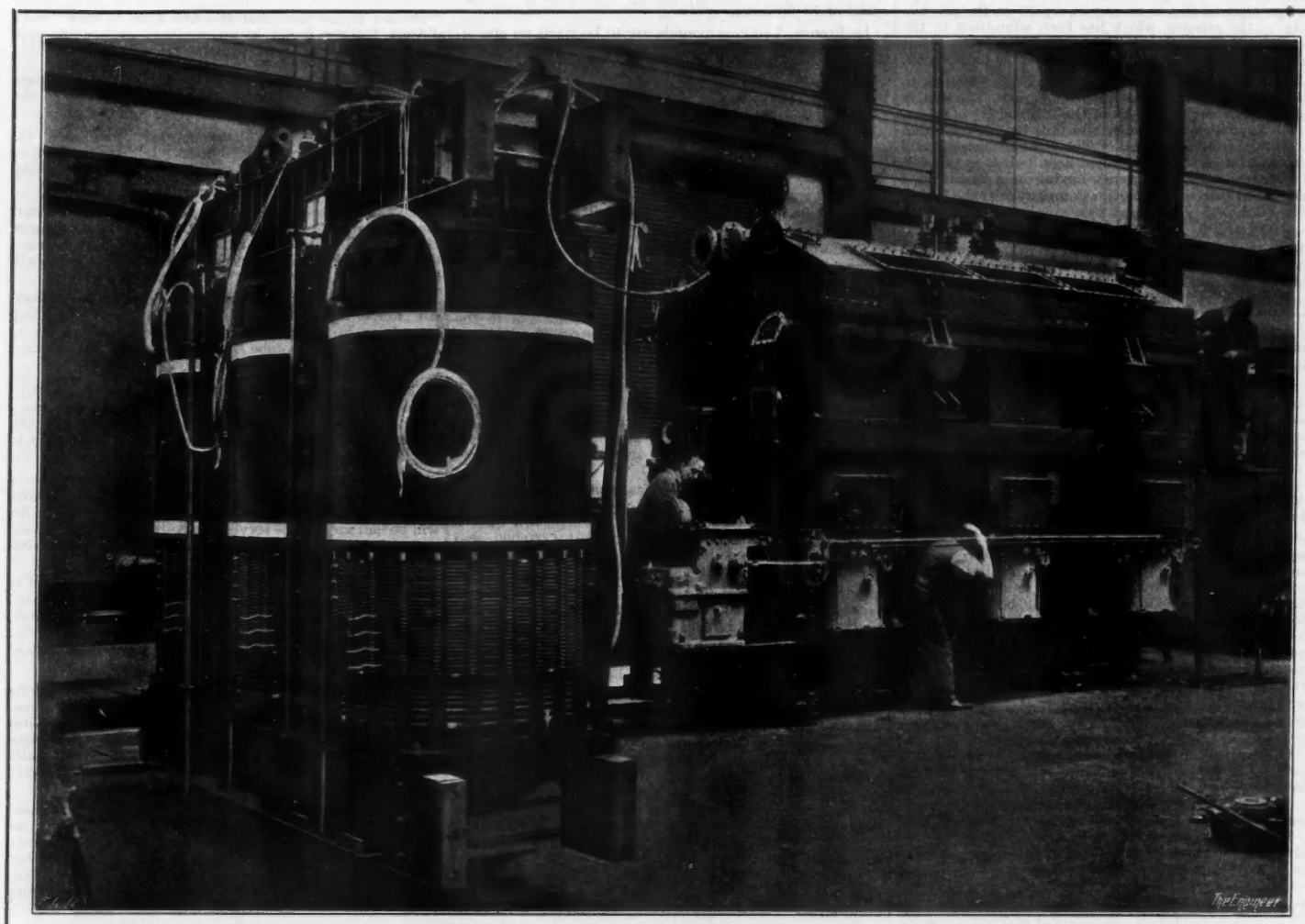
WORK is progressing rapidly on the "Queen Mary." Both masts and two of the funnels are now in position and the third funnel will be placed before the end of the month. All the heavy machinery is in position and the work of connecting up has been begun. When launched on September 26th last she was drawing 17ft. of water at the bow and 24ft. at the stern. Now she is drawing 21½ft. forward and 33ft. aft, and these figures will be increased to 40 and 44 respectively before departure. Dock trials will take place next May.

A REPORT has been submitted by the delegates appointed by the Llanelly Harbour Trust to visit German ports before ordering additional coal shipment equipment for Llanelly North Dock, on plant inspected at Cologne, Duisberg and Bremen. This plant, electrically worked, was capable of a maximum delivery of 300 tons per hour and would save 75 per cent. of the breakage of coal by the present method of hoist and chute. This was capable of fully meeting the requirements of the port. Excepting certain patented parts, this plant could be made in Great Britain by British workers from British materials.

IN his speech at the launch of the "Umtata," Mr. J. Denham Christie said that in 1914 some 1,750,000 tons of shipping were under construction in this country and in the worst of the depression in 1932 the amount fell to 225,000 tons. By the end of last year the total rose to nearly 600,000 tons. The figure had fallen again for the first six months of this year, but during the past three months the inquiries received gave reason to hope that the figure for 1934 would be exceeded. He went on to say that few, if any, of the merchant ships now under construction were being built at profitable prices and that at the end of June 70 per cent. of the shipbuilding berths in this country were idle.

THE WORKS OF THE BRITISH ELECTRIC TRANSFORMER COMPANY, LTD., AT HAYES

(*For description see page 274.*)



ABOVE:—10,000-KVA THREE-PHASE GRID TRANSFORMER

BELOW:—THREE 8,000-KVA SINGLE-PHASE TRANSFORMERS IN COURSE OF CONSTRUCTION

The Engineer

SEPTEMBER 13, 1935.

VOL. CLX. No. 4157

Contents.

THE ENGINEER, September 13th, 1935. PAGE

A SEVEN-DAY JOURNAL .. 257
ELECTRIC DRIVING. No. IV. (Illus.) .. 258
ELECTRO-MAGNETIC TESTS FOR THE WORK-HARDENING OF STEEL WIRES. (Illus.) .. 260
THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA. No. I. (Illus.) .. 263
SOUTH AFRICAN ENGINEERING NOTES .. 265
ELECTRIC LOCOMOTIVES FOR THE SOUTH AFRICAN RAILWAYS. (Illus.) .. 266
THE TAWA FLAT DEVIATION, NEW ZEALAND .. 266
SIXTY YEARS AGO .. 266
RAIL AND ROAD .. 267
MISCELLANEA .. 267
AIR AND WATER .. 267
LEADING ARTICLES—
The Dynamics of Sea Waves—Reaction to New Ideas .. 269
THE BRITISH ASSOCIATION. No. I .. 270
XVITH INTERNATIONAL CONGRESS OF NAVIGATION, BRUSSELS, 1935. (Illus.) .. 272
INSTITUTE OF METALS. No. I .. 274
LETTERS TO THE EDITOR—
High-speed Trains and Vibration .. 274
A VISIT TO A TRANSFORMER WORKS. (Illus.) .. 274
THE FEATHERSTONE MOTOR CAR LOCK. (Illus.) .. 276
A HEAVY DUTY SLOTTING MACHINE. (Illus.) .. 276
MECHANICAL LEAD JOINT FOR CAST IRON PIPES. (Illus.) .. 276
LIQUID GAS .. 276
WORLD LAND SPEED RECORDS .. 276
METAL MELTING—ITS EFFECT ON QUALITY. (Illus.) .. 277
CATALOGUES .. 278
MARKETS, NOTES AND NEWS .. 279
CURRENT PRICES FOR METALS AND FUELS .. 280
FRENCH ENGINEERING NOTES .. 281
BRITISH PATENT SPECIFICATIONS. (Illus.) .. 281
FORTHCOMING ENGAGEMENTS .. 282
CONTRACTS AND ORDERS .. 282
LAUNCHES AND TRIAL TRIPS .. 282

TWELVE-PAGE AND FOUR-PAGE SUPPLEMENTS—"THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA."

NOTICES TO READERS.

**** If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

**** For Subscription rates, see page 2 of Advertisements.*

**** All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

**** No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGES OF ADDRESS.

**** Will subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

THE DYNAMICS OF SEA WAVES.

AMONG the subjects discussed by the fourteenth International Congress of Navigation at Cairo in December, 1926, was that of breakwater construction. One result of the discussion was the appointment of a small international committee of experts to study the stresses due to waves in breakwater structures and the instruments most appropriate for their measurement. This committee, which includes representatives of France, Germany, Italy, Spain, Chile, and Great Britain, has assembled on various occasions since 1927, and experimental work has been organised in several of the countries named. The British representative on the committee is Sir Leopold Savile, who, at the time of his appointment, was Civil Engineer-in-Chief at the Admiralty. French engineers have carried out experimental work at Dieppe and Algiers, and Spain has undertaken observations by means of hydraulic dynamometers at the ports of Gijon, Valencia, and Bilbao. So far as Great Britain is concerned, experimental work with hydraulic and electrical instruments is, we understand, to be undertaken at Peterhead. But the most interesting experiments so far carried out, the results of which have been published, are the observations made at Genoa by means of recording instruments, incorporated in a specially constructed sectional unit of the Principe Umberto mole at that port. Some account of these experiments is contained in a paper by Professor Salvatori Levi recently published in the Italian journal *L'Ingegnere*, and they were also described by Signor Coen Cagli in the lecture delivered by him before the Institution of Civil Engineers in July last, to which reference was made in one of our leading articles two weeks ago.

The measurement of the forces exerted by waves by means of recording instruments is not in its essentials a novel undertaking. Nearly a hundred years ago Thomas Stevenson devised an instrument, which he called a marine dynamometer, by means of which he measured the pressures exerted by waves on small discs connected by springs with a simple recording indicator. He obtained at the Skerryvore Rocks, off the West Coast of Scotland, which are exposed to the full force of the Atlantic waves, a record of 2·7 tons per square foot, and at a later date recorded a maximum reading of 3·5 tons with an instrument at Dunbar. But there is little analogy between Stevenson's experiments and those carried out at Genoa and elsewhere in the past few years, for it is probable that the high values he obtained were the result of the pounding of breaking waves at about water level and in relatively shallow depths, whilst the westward extension of the Principe Umberto mole at Genoa is built in a depth of water of about 20 m. The structure has a maximum exposure on a line about S.S.W. approximately normal to the sea face of the breakwater. The recording piezometers are placed in a series of water-tight chambers formed in the vertical blockwork wall of the mole at seven different levels varying from 3 m. above the zero water level to 10 m. below zero. The tidal range at Genoa is insignificant, being about 1ft. at springs. The instruments are arranged in one vertical line so that continuous and synchronous records of wave pressures are obtainable at different levels. The piezometers are mechanically connected with a recording apparatus, placed within the wall structure, and electrically with an oscillograph in a tower at some distance from the mole, which is accessible at times when the breakwater itself cannot be visited owing to stress of weather. The Genoa observations were begun over four years ago, and the results so far recorded during storms have been limited to waves not exceeding 5 m. in height (in the open sea) incident at about right angles to the face of the breakwater. The records show that the positive pressure (compared with the static pressure due to the level of calm water) exerted by a wave of undulation reaches a maximum generally a little below the level of calm water, and that the maximum pressure is very nearly equal in all cases to the hydrostatic pressure due to the height of the unobstructed wave in the open sea. The stress diminishes rapidly above the level of calm water; but, on the other hand, the positive maximum pressure diminishes below calm sea level more slowly as the ratio of height to length of wave is reduced. In the case of waves of ordinary proportions the pressure is reduced at the foot of the wall to a value which always exceeds one-half the maximum pressure, while it remains sensibly uniform and equal to the maximum, through the whole range of levels below calm sea level, in the case of waves which are exceptionally long in relation to their height. Moreover, it has been observed that the negative effort below the trough of the wave in contact with the wall is approximately equal at all levels to the corresponding positive pressure. In order to check the Genoa results, and with the object of analysing the circumstances attending the disasters at Catania and Algiers, of which an account is given on another page of this issue, experiments have recently been carried out in the Hydraulic Laboratory at the University of Lausanne by Signor Coen Cagli and Professor A. Stucky, of Lausanne, with scale models of the breakwaters at Genoa, Catania, and Algiers. These experiments, in some of which the French engineers responsible for the Mustapha jetty at Algiers collaborated, showed an almost perfect agreement of the actual instrumental observations made at Genoa with the corresponding tests of the model of the Principe Umberto mole, thus indicating that the method of research by means of tests on small-scale models, based on the law of dynamical similitude, is strictly applicable to the study of wave effort. Moreover, as Signor Cagli points out, the model experiments show that undulating waves, in violent storms, at any rate, are not converted by reason of their reflection at the face of a vertical wall into actual "standing waves" (*clapotis*), but maintain their essential characteristics as trochoidal waves with orbital, though modified, movement, and they exert pressures that notably exceed those which would be produced by an essentially standing wave engendered by the same trochoidal wave. The laboratory experiments with models of the Mustapha and Catania breakwaters showed that in the case of the former, waves 9 m. in height in the offing (such as those which brought about the collapse of the jetty) exerted a positive pressure at the level of calm water of 8·7 tons per square metre and a total effort of 147 tons per lineal metre of the structure, greater by 35 per cent. than that which would be exerted by a standing wave of the same length and 18 m. high alongside the wall. The Catania model, tested with waves 7·5 m. high in the offing, similar to those observed during the storm which destroyed the mole in March, 1933, showed a total effort of 129 tons per lineal metre of structure, a pressure quite insufficient to cause overturning, had the wall been monolithic, but more than enough to account for the destruction of the mole by the successive sliding of disconnected masses on the horizontal joint planes of the blockwork.

Neither the actual observations of pressures at Genoa nor the experiments on small-scale models hitherto made can be considered as exhaustive; but, in Signor Cagli's opinion, the following conclusions as to wave effort are justified in the present state of experience, observation, and research, whether theoretical or experimental:—(i) Any danger of the complete breaking of storm waves in front of a vertical wall breakwater is excluded when the depth of water at the site of the work is at least twice the height of the greatest storm waves likely to be encountered in the locality, whatever be their length, and if the foot of the vertical wall is at a depth of at least $1\frac{1}{2}$ times the same height; (ii) the total maximum effort to which the wall may be exposed by the maximum wave stroke likely in the locality can be calculated on the basis of a unit pressure equal to the hydrostatic pressure due to the total height (from trough to crest) of the waves in the open sea applied uniformly throughout the whole extent of the wall below calm sea level; (iii) above calm sea level the intensity of effort diminishes progressively in the ratio of about two-thirds of the height—for instance, with a surface level pressure of 8 tons per square metre, the unit pressure at 3 m. above calm sea level would be reduced to 6 tons per square metre, and (iv) the width of the berm at the foot of the wall and the inclination of the side slope of the rubble mound do not affect in any way the intensity of the stroke exerted by the waves against the wall.

Reaction to New Ideas.

IN the July issue of the *Bulletin* of the British Engineers' Association there was reprinted a monograph by "Callisthenes." After referring to what is known by psycho-analysts as the "association-test," the author asks: "What is our reaction when a new idea is placed before us? To get at the real tone and structure of our mind, we have to note the first, instinctive automatic reaction. If we wait a minute or two it will become confused with matters of policy. We will ascertain the authority behind the idea and then decide that for reasons of prudence we must appear to welcome it. Even the most energetic and open-minded can get a surprise when they discover how often the first reaction is towards refusal. There is a closing of the eye as at the approach of a blow. Inertia has had its say before energy and judgment could be consulted." We confess that our own immediate idea-reaction to this passage is: "Well, what about it? What does it matter what our 'first instinctive, automatic reaction' is so long as we do not allow it to influence our reasoned opinion?" Probably the natural reaction of everybody to anything that will change the course he is at the time comfortably pursuing is repulsion. Yet, no doubt, there are some who, under psychological training, succeed in deceiving themselves into the belief that they have no mental inertia at all, that they are ready at any time, and without an instant's preparation, to welcome a new idea. Inertia is such a universal phenomenon of nature that it is as impossible for any man genuinely to rid his mind of it as it is to remove it from a stone cast by a sling. The inertia—possibly we use the term more strictly in its scientific sense than does "Callisthenes"—may cause us to feel a sudden opposition to new ideas, but, equally, if, by psychological exercises, we make our minds too easy-going, we may waste time on ideas that are not worth a moment's consideration. It does not matter a jot what our first thoughts are. They are necessarily illogical. Only when objection to new ideas sways our reason does it become dangerous.

The first "instinctive, automatic reaction" is, we suggest, of no consequence to anyone but the psychologist. We are, of course, excluding those instinctive reactions which civilised man has learnt to control, and we are assuming that the person under consideration is capable of forming logical judgments. With this much premised, we venture the opinion that a primary, involuntary, sense of opposition may be even more useful than a sudden unreasoning welcome. The opposition is the offspring of experience, which, for obvious reasons, the welcome can only be in exceptional cases. The manufacturer who has been doing certain things in a certain way with apparent or real success, has, so to speak, pigeon-holed his reasons for believing that way to be the best. His natural

reaction is an objection to anyone opening up one of his pigeon-holes. The thing would not have been done, in the first place, were there not good reason for doing it. A new reason, outweighing the old, for undoing it must therefore be advanced. It is, wrote Bacon in a familiar essay, "well to beware that it is the reformation that draweth on the change, and not the desire of change that pretendeth the reformation; and lastly that the novelty, though it be not rejected, yet be held for a suspect." Every innovation is, in part or in whole, a condemnation of what exists, and our natural and first instinct is to protect the old from attack. It seems, therefore, that the first "instinctive, automatic reaction" should be one of resistance, and that the psychologists are mistaken in assuming that such a reaction should be, or indeed can be, overcome by mental calisthenics. Even when the innovation is something novel in itself, a new proposition which adds to and does not overthrow anything already in being, a sudden willingness to welcome it may be more harmful than a defensive attitude. Everyone of us knows men who in their readiness to accept new ideas bolt them as soon as they are presented, and have to disgorge them when calm reasoning has shown their fallacy. On the other hand, a little primary bias in opposition strengthens decisions.

In no walk of life is it more necessary to study innovations than in technology, and in few is it so often difficult to reach the right conclusion. The innovator who sees an old machine tool in a factory at once condemns the owner for retaining it; the railways are charged with the deafness of old age because they will not listen to the electrificationists, or exchange motor coaches for express trains; the boiler insurance companies are censured for their conservative policy with regard to welding. In every branch of engineering someone is blamed for doing something that the innovator thinks should not be done, or for leaving undone something that he thinks should be done. Yet, allowing always that human wisdom can never attain complete efficiency, it must be admitted that, with rare exceptions, if and when the arguments in favour of the change outweigh the arguments against it, the change is adopted. Now and then a supine mind resists or refuses to listen to arguments which should convince it; an error of judgment is made, and the punishment inevitably follows. But it is not the first harmless reaction against an innovation, but the persistent and unreasoning recalcitrance in the face of effective arguments that brings destruction. When prejudice comes in at the door, judgment flys out at the window. We believe such cases grow rarer and rarer in the realm of engineering, and that the fault is more often caused by the difficulty of forming a right judgment amongst complex and conflicting arguments, than by an unwillingness, despite the "first instinctive, automatic reaction," to listen to the claims of the innovator.

The British Association.

No. I.

AFTER a period of sixty-seven years, the British Association for the Advancement of Science held its meeting in Norwich this year—from September 4th to 11th. The Evening Discourses included one by Dr. S. J. Davies, dealing with Diesel Engines in relation to Coastwise Shipping. A feature of the meeting was an Exhibition of "Scientific Aids to Management," and among the exhibits was one by the London School of Hygiene and Tropical Medicine, which included photographs and models illustrating modern methods of heating, lighting, ventilation, and dust removal in factories from the standpoint of health and efficiency of workers. Among the other exhibitors were the Anti-Noise League, the British Standards Institution, the Industrial Health Research Board, and the International Committee for Scientific Management, which latter exhibits charts of a hypothetical "Ministry of National Efficiency."

Following the established custom, the inaugural general meeting of the Association took place on Wednesday, September 4th, at 8.30 p.m., when the President of the Association—Professor W. W. Watts, F.R.S.—delivered an address on "Form, Drift and Rhythm of the Continents," part of which was reprinted in our issue of last week.

The announcement was made that Sir Josiah Stamp will be the President of the Association in succession to Professor W. W. Watts, and that the meeting next year will be held in Blackpool. Nottingham will be visited in 1937, and Cambridge in 1938.

At the opening meeting of Section G (Engineering) on Thursday morning, September 5th, the chair was taken for a few moments by the retiring President of the Section, Professor F. G. Baily, who introduced the new President—Mr. J. S. Wilson—and referred to the yeoman service which he had rendered to the Section as recorder for very many years.

Mr. Wilson then took the chair. In presenting his address on "The Stability of Structures"—see our issue of last week—he departed from the custom of just reading what had been printed, and enlivened it considerably not only by showing a number of lantern slides, but by the manner in which he interposed amusing comments on some of the things he had already written and indulging in one or two delightful witticisms at the expense of certain engineers who many years ago were engaged in structural work coming within the scope of his address.

Sir Thomas Hudson Beare, who proposed a vote of thanks to the President, which was cordially given, spoke of the value of the address in demonstrating how we can benefit from the failures of the past and mistakes with regard to theory as well as those on the practical side, a striking example being the problems of the suspension bridge, which had been dealt with in such an entertaining manner. The suspension bridge type, he continued, had been improved enormously in recent years, outstanding examples being now found in the United States. The old fear of running a railway line across a suspension bridge had now disappeared, and there was no hesitation in doing so over suspension bridges with spans which would almost have frightened engineers into fits years ago. He had been particularly interested in what the President had said concerning the controversy with regard to masonry dams. The fact that masonry dams designed and built many years ago had proved to be perfectly safe and sound suggested that the mathematical difficulties which had been anticipated by Professor Karl Pearson were really not so difficult after all. The failures of masonry dams had been extremely few and the fact that there existed all over the world some very lofty masonry dams proved that the theory on which engineers had based their work had been, on the whole, sound and satisfactory.

REDUNDANT STRUCTURES.

The first paper read on Thursday morning in Section G was by Professor R. V. Southwell, F.R.S. It took the form of a short address on "A New Method of Solving Redundant Structures," and was of an extremely mathematical and complicated nature, although introducing a considerable degree of simplicity as compared with existing methods.

The author gave an account of the methods he has developed using as the basis an article which appeared in the August "Proceedings" this year of the Royal Society. He has introduced what he calls the "relaxation method," in which attention is fixed upon the forces on the constraints, everything depending upon the solution for a single member. The first step—as was shown mathematically—in relaxation methods is to calculate the influence coefficients appropriate to every member, and it was shown how, knowing the influence coefficients, it is possible to calculate the effect of any relaxation. From these calculations, elaborate tables have been constructed. By this method, it is claimed, all the thinking is done once for all, and after that nothing is needed beyond the first four rules of arithmetic. Secondly, it was pointed out that the calculations are stopped when the residual forces are within the accuracy of the data, and, finally, the consequences of any assumptions made are known.

The President congratulated Professor Southwell on the manner in which he had explained an extremely difficult thing.

Sir T. Hudson Beare remarked that it was difficult to follow a work of that kind without first having had an opportunity of studying the principles laid down. Nevertheless, it was clear that the method described would relieve structural engineers of an enormous amount of work in dealing with redundant members in structures. The whole thing apparently boiled down to simple arithmetic, having found the fundamental equations and fundamental principles. The idea was a very beautiful one, and structural engineers and those concerned with structural design work would appreciate the great advance made by the method suggested by Professor Southwell. He understood it was just as easy to apply it to structures in three dimensions as to a simple plane structure.

Wing-Commander Cave-Brown-Cave (recorder, Section G) said it would be interesting to see a framework solved by the old and the new methods in order to compare the relative complexity of the two and the ease of checking. It seemed to him that although the old method involved mathematics of considerable difficulty, the new method appeared to involve incomparably more work, but of a very much simpler nature. That being so, which would be the easier to check?

Professor Southwell replied that in each of the two complete papers—the one already published and one yet to be published—he had made a solution on orthodox methods as well as by the new method. With the former if a mistake were made it was very hard to trace it and checking was not so easy as in the new method, since in the latter it was possible at any stage in the process to carry out a check by the aid of the calculations and tables that had been prepared.

Dr. J. G. Docherty said that with the new method it was possible to stop at any degree of approximation that was required, and from the educational point of view that was an immense advantage. Too often at present students made use of the slide rule and gave some extraordinary results, and never thought about the data from which the answers were derived. The new method would prevent that sort of thing, and that fact alone, apart from anything else, seemed to make the method well worth while.

The only other paper presented this morning in the Section was the Report of the Committee appointed by Section G in 1928 to consider Stresses in Overstrained Materials. It was presented by the Secretary of the Committee, Dr. J. G. Docherty.

STRESSES IN OVERSTRAINED MATERIAL.

The Committee directs particular attention to overstrain in mild and moderately high-tensile steels as used in current structural and general engineering practice in bridges, buildings, high-pressure pipe lines, and other applications in which safety depends directly on the avoidance of undue plastic overstrain in the ductile metal. It is pointed out that the need for reconsideration in this particular matter arises in part from the increasing use of electric and other methods of welding in lieu of riveting in structural and general practice. While the practice of welding eliminates certain difficulties and dangers, it leaves the problem of plastic overstrain more prominently in the position of the limiting factor in design in many cases of economic importance, and in such circumstances it appears desirable that current methods of design should be adapted to recognise the danger of plastic strain in a more definite and formal manner, so that the margin of safety of a structure under its working loads may be judged by direct comparison with the overloads that would be required definitely to produce undue plastic overstrain in the ductile metal.

The investigations carried out by the Committee confirm the view that has long been held by many engineers that the elastic limit in the case of mild or moderately high-tensile structural steel is unsuitable for use as a reference value for purposes of design. The value depends unduly upon the method of testing adopted, and when special precautions are observed to ensure that scientific accuracy is attained, the value appears to be much higher than is generally believed, and misleading for general application.

The yield point of the material is considered to afford a more reliable basis for design in cases where plastic overstrain is regarded as the limiting factor; but the yield point also—as now generally measured in accordance with current standard specifications—is open to the objection that the value also varies according to the method of testing and probably with the rate of application of load in the tensile test.

The so-called "lower yield point" has been studied with particular attention, and is considered to afford the most satisfactory and reliable basis for the comparison of structural steels and for the design of structures in which plastic overstrain must be limited, and it is recommended that a specification of the lower yield point should be adopted for the use of those who may desire to employ it. At present, although the lower yield point is already used by many who have experience of its advantages, no specification for its measurement appears among the British Standard Specifications for yield point.

The advantages of the lower yield point, as a basis for the comparison of different structural steels and as a basis for design, are summarised as:

(1) In samples of mild or moderately high-tensile structural steel, the value of the lower yield point is readily determined in any ordinary tensile testing machine without the use of an extensometer or other sensitive or costly equipment.

(2) Consistent values are obtained without any undue change in the current procedure for tensile testing, and are likewise obtained when the method of procedure is varied within limits to permit of changes to suit local conditions.

(3) Although the value depends perceptibly upon the rate of straining adopted in the test, the variations that may be found when the rate is restricted during a brief stage of the test are only slight and not of practical importance.

(4) The determination of the lower yield point during the course of an ordinary tensile test should not add greatly to the total time required for the test.

(5) In structural members, such as tie bars, columns, beams, tubes, and the like, of mild steel or moderately high-tensile steel, subject to determinate conditions of loading, the overloads required to cause undue plastic overstrain are readily calculated in terms of the lower yield point of the steel employed.

(6) In welded structures comprising members subject to determinate loading, the calculated overloads required to cause undue plastic overstrain are closely confirmed in tests, when the joints between the members are of reasonable design.

(7) In welded structures of complex design, the margin between the actual load and the calculated overload (at which undue plastic overstrain may be expected to occur in the light of calculations based on the lower yield point of the steel) affords a serviceable guide to the designer.

In view of these considerations based upon investigation and experience, it is considered that the tensile lower yield point offers advantages that justify its more general application in connection with structural design in mild and moderately high-tensile steel; but its application at present is restricted by the lack of an accepted British Standard Specification.

The following draft of such a specification is submitted for consideration:—

> "After yield has commenced in a tensile test on a standard piece (comprising a portion that is tolerably uniform in section), and before it has spread along the whole of the portion of uniform section, the load shall be readjusted to a new, steady value (being reduced, if necessary) so that yield spreads along the uniform portion while the machine continues to elongate the piece slowly (at a rate not exceeding $\frac{1}{16}$ in. per minute). The stress value deduced by dividing the readjusted load by the initial cross-sectional area of the uniform portion of the test piece shall be known as the lower yield point."

The Committee recommends that the desirability of adding a specification of the lower yield point to the specifications of other properties of mild and moderately high-tensile steel be brought to the notice of the British Standards Institution.

Finally, it is pointed out that the terms of reference, "to investigate the stresses in overstrained materials," were extremely wide, and the Committee has investigated one

important aspect of the problem. The members do not ask to be reappointed, but suggest that further investigation of some of the special problems involved deserves serious consideration.

In commenting on the work of the Committee and putting forward the recommendation, Dr. Docherty remarked that "stresses in overstrained materials" was a very vague term, but he believed the intention originally was to deal in stresses resulting from pressing and stamping. On further consideration, however, the Committee decided to concentrate on an investigation of the behaviour of metals, and especially mild steel, in the neighbourhood of the yield point, and Dr. Cook had carried out some very fine work on the plastic overstrain in the case of the simpler geometrical types. A good deal concerning that work was published in the Report of the Committee for 1931. Out of it, however, there emerged the definiteness of the lower yield point, and also the absence of any definite specification. A further matter was that yield point was probably more important now than it used to be. It was becoming more and more a factor which the designer desired to know as compared with, in former days, ultimate tensile strength. One reason for that was the greater variety of steels now available, and another was the increasing use of welding. The object of the recommendation was to ensure that there should be, for those designers who desired to use it, a standard specification of the actual stress at which the plastic strain commenced and continued.

Noise.

It had been the intention, according to the programme, to take the Report of the Committee on Noise on Wednesday morning, September 11th, in Section G, but owing to the fact that a recommendation was to be placed before the Section and that all resolutions from Sections had to reach the Council of the Association before that day, it was decided to deal with this particular Report the first thing on Friday morning, September 6th.

In the absence through indisposition of Sir Henry Fowler (Chairman of the Committee), the Report was presented by the Hon. Secretary of the Committee, Wing-Commander Cave-Brown-Cave, who mentioned that Section G Committee—if the recommendation was agreed to—would pass it on to Section A, where Professor Kaye was giving an experimental lecture on the subject, and the support of Section A, if given, would be of the greatest value in securing further action on the part of the Association.

The Report of the Noise Committee recalled that at the meeting in Aberdeen last year it was decided that the Committee should remain in being to watch and report progress. It was granted £5 for correspondence. At that meeting it had been demonstrated that by using certain silencers which had been devised and made at University College, Southampton, the exhaust noise of representative motor bicycles could be reduced to an inoffensive level without loss of power or any practical disadvantage. The principles on which these designs had been based were explained at the Aberdeen meeting in order that they might be used as freely as possible. To facilitate the introduction of effective silencers it was suggested last year that the Minister of Transport should set up an organisation whereby each new type of machine could be tested for a certificate of approved silence. The Minister had appointed a committee to report to him on the whole question of transport noise, but it was understood that until the committee had reported, no information as to the work it had done, or conclusions or the action likely to be taken, could be communicated. It was known that several firms had constructed satisfactory silencers based upon the principles described to the British Association, but they were not likely to be adopted as standard until all manufacturers had effectively to conform to a definite standard of silence. The Minister of Transport presided at a lecture to the Royal Society of Arts, in which Wing-Commander Cave-Brown-Cave gave a further description of his work on silencers and the Minister expressed appreciation of the value of the results achieved.

A pair of silencers had been made for the Royal Automobile Club of Holland. They were arranged to be identical except that one was packed and the other unpacked, but made with special perforated tubes described to the B.A. last year. A careful comparison of these silencers showed that of the two, the unpacked one was slightly more effective. The manufacturers, continued the Report, consider that sufficient information about the design of exhaust silencers is now available and they have made to Wing-Commander Cave-Brown-Cave a further grant of £50 to investigate the suppression of carburettor noise, as that, in many engines, became the dominant one when a good exhaust silencer was fitted.

After reporting that his expenses in connection with correspondence exceeded the £5 grant last year, Wing-Commander Cave-Brown-Cave put the following recommendation before the Section :—

> "In connection with the demonstration given at the Aberdeen meeting a year ago of effective silencers made for the engines of bicycles, the Association understands that the general problem of noise of motor transport is still under consideration by the Committee appointed by the Minister of Transport, and that until that Committee reports no information about their work or proposals can be communicated.
>
> "While recognising that there are administrative difficulties in giving practical effect to the improvements which technically are possible, the Association expresses the hope that the Minister will make arrangements whereby new motor bicycles may be type tested to ensure that they comply with a certain standard of silence, even though that standard might initially be a very lenient one.
>
> "The Association draws attention to the great popular desire for improvement, and also to the great extent by which many vehicles do exceed any noise level which could reasonably be defended as scientifically or technically necessary."

The President, in supporting the recommendation, said that whilst allowance could be made for machines that became old and the inability of the owners to spend money upon them, there was a class of machine which infuriated the average member of the public, viz., the so-called sports cars, which were intentionally made noisy with an entire disregard for the feelings of other people and merely for the satisfaction of those who owned them. There was not the excuse that these cars were old ; for the most part they were comparatively new, and if the Committee's recommendation gingered up the authorities to put into force some regulations which would prevent such noisy vehicles being allowed on the road or being produced, everybody would be extremely pleased.

Professor W. Cramp, who also supported the recommendation, said he had been informed by some of the largest manufacturers of the particular type of car to which the President had referred that they would be only too pleased to reduce the noise if it were not for the fact that they would not then be able to sell the machines.

The recommendation was then unanimously adopted by the Section.

Problems in Fen Drainage.

Major R. G. Clark then presented a paper in which he discussed the various problems which arise in fen drainage, which he illustrated by a number of photographs and maps. It was estimated, he said, that about 1,279,000 acres of fenland and lowland in England and Wales were protected by artificial works from inundation by the sea or flooding from the rivers conducting the surplus water to the sea. All this land was in the areas of the Catchment Boards, and it was probably no exaggeration to say that it included some of the richest agricultural land in England.

The fenlands problem as regarded defence against water might be divided, in the first place, into two parts, *i.e.*, their protection from inundation from the tidal rivers and upland floods, and the evacuation of the water in their own area so as to avoid internal flooding.

Dealing with the first, Major Clark said that in several cases the areas had been reclaimed from tidal influence and protected by means of sea-wall embankments and barrier banks from the year 1500. Referring to the work of Vermuyden, the Dutch engineer, who constructed several barrier banks, new cuts, &c., in the Bedford Level area about 1631, he said that those barrier banks had stood the test of time, although the materials available for them were only clay, silt, and gravel. The artificial by-passes or short cuts which Vermuyden made for the rivers were intended to conduct the flood waters from the uplands through the low-lying fenland areas to the outfall. It was just possible that if his works had been maintained properly and improved from time to time, the condition of the main rivers and their outfalls would not have presented such a problem as it did to-day.

Generally speaking, the main rivers, especially the tidal portions, needed correcting, particularly at estuaries or outfalls. Erosions and accretions in the river banks required constant attention. In many cases the state of a river was due to the ill-conditioned state of the estuary. Perhaps if the estuaries were put in order and training walls were carried out to deep, clear water, the tidal portion of the rivers would not become worse, but might in the course of time become self-cleansing.

It was questionable whether it was sound policy to make the rivers larger in order to accommodate winter floods, in view of the long drought periods that followed. It might be worth considering the provision of works so that relief might be given during peak periods of floods, thus equalising more nearly the summer and winter run-off, by a system of washlands or reservoirs above the tidal section of a river. In some cases flood areas in a river were provided for by flood banks set back from the river banks ; such flood banks added very considerably to the flood capacity of a river and might be more economical than widening the river channels.

Coming to the problem of the evacuation of the water to avoid internal flooding, the author pointed out that the fen areas were near the outfalls of the rivers and were well below high-tide level. In several parts of Fenland the lowest level was furthest from the outfall sluices and often the low land was found to be shrinking more than the high land, so that the problem was to drain the low land through the high land. As the level of the land varied considerably in those areas, they were generally intersected by internal high-level main waterways or drains, the areas being subdivided into minor internal drainage districts. The main internal waterways were often embanked and acted as high-level conduits to the outfall sluices, which were in many cases under tidal influence and control. The minor districts each evacuated their surplus water into the main waterways, generally by pumps, and each district was self-contained.

The author traced the improvements effected in regard to the plant used for lifting the water in the minor internal districts, from the windmills and scoopwheels used many years ago to the modern oil engines, and added that efforts had been made to obtain a supply of electricity ; but so far the cost had been too high, owing probably to the low load factor. In the Middle Level, he said, there were about sixty pumping plants pumping water from the minor districts to the Middle Level high-level system of waterways.

After a description of some of the difficulties of the problem, the author concluded that although vast sums had been expended on those areas in the past, it was evident that in the future very considerable expense would have to be met ; it was doubtful, however, whether much could be done without State assistance. Naturally, the expense of protecting and draining the fenlands was heavy ; in some areas the flood water was pumped twice or even three times before it discharged to the sea. Prior to the passing of the Land Drainage Act, 1930, the bulk of the drainage rates was based on acreage, but it had since been based on annual value so far as agricultural land was concerned, and one-third the rateable value for houses and other hereditaments. During the past twelve years the Middle Level Board had spent over £500,000 on new works and maintenance,* and during that period the State had contributed liberally to drainage works on the recommendation of the Land Drainage Branch of the Ministry of Agriculture and Fisheries. It would be a national disaster if these large food-producing areas of fen and low lands were not maintained and protected. It might be argued that it was in the national interest to encourage schemes of magnitude by way of grants, which, incidentally, provided work for large numbers of men and rendered the areas safe from inundation.

Mr. R. W. Allen, speaking of fen pumping, said that after giving a good deal of consideration to the subject he was satisfied that the most efficient mechanical means for driving pumping machinery for that class of work was the oil engine. It had the advantage of being able to be started and stopped very quickly, and depreciation and overhaul were very small.

Lieut.-Colonel E. R. Pratt asked how the machinery described in the paper was controlled when pumping tidal water. Was there automatic control which provided that the plant came on the moment gravity flow ceased and automatically went off the moment there was sufficient head to ensure gravity flow ? If that were not the case, then with a rapidly moving tide it might be that at one moment they would be pumping against a 2ft. head and a quarter of an hour later against a head of 8ft., when it would not be economical.

The author replied that there were tide indicators in the engine-house showing the tidal level so that the man in charge could see the difference in tidal head. The tachometer showed the economical speed to work at, and at about 15ft. head the engines were cut off. Generally, however, the pumping went on for three parts of the time. The man was instructed in the winter time not to allow the water to go above a certain mark on the suction side, and he had to accommodate the conditions on the delivery side. There was nothing automatic about the plant, except as regards the levels.

The remainder of the morning in Section G—nearly two hours—was occupied with a lecture entitled "The Present Position of Television," which was given by Captain A. G. D. West, of the Baird Television Company, who not only fully illustrated his remarks, but gave a number of highly interesting demonstrations. This lecture will be reported in our next issue.

(To be continued.)

BOOKS RECEIVED.

The Railway Handbook, 1935–36. London : *The Railway Magazine*, 33, Tothill-street, S.W.1. Price 2s. 6d. net.

Fans. By T. Baumeister, jun. London : McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 21s. net.

Power Operator's Guide. By E. J. Tangerman. London : McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 24s. net.

Anuario de la Gran Bretaña, 1935–36. London : Trade and Travel Publications, Ltd., 14, Leadenhall-street, E.C.3. Price 2s. 6d. net.

Seaplane Float and Hull Design. By M. Langley, M.I. Ae. E. London : Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 7s. 6d. net.

Practical Mechanics of Motion. By J. F. Mangold. London : McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 12s. net.

Steam Turbines. By C. S. Bradshaw, A.M.I. Mech. E. London : Draughtsman Publishing Company, Ltd., 96, St. George's-square, S.W.1. Price 2s. net.

Modern Radio Communication. Vol. 2. By J. H. Reyner, B.Sc. London : Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 7s. 6d. net.

* See THE ENGINEER, September 28th, 1934, "Middle Level Pumping Station and Sluices."

XVIth International Congress of Navigation, Brussels, 1935.

No. 1.

OF the questions submitted for discussion at the Sixteenth International Congress of Navigation, which assembled in Brussels on September 2nd, that which attracted the greatest attention is the second question in Section II, "Design of Breakwaters with Vertical Sides: Effect of Wave Action Thereon; Lessons Gained from Experience." This subject produced eight reports by members of the Congress, of which the most interesting are those by Signor Coen Cagli, of Italy; Messieurs Benezit and Renaud, which deals with French and Algerian breakwaters; and Senor Jorge Lira, writing from Chili. We print hereunder a somewhat shortened version of Signor Cagli's paper, which contains a critical account of the failures of two important breakwater structures in the Mediterranean, that at Catania, which finally collapsed in 1933; and the Mustapha Jetty at Algiers, the outer arm of which was overturned during a gale in

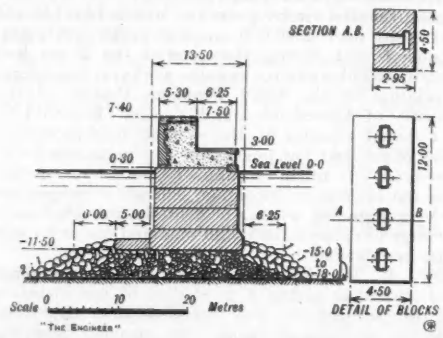


FIG. 1—PRINCIPE UMBERTO MOLE, GENOA, BETWEEN 1545 M. AND 2315 M.

February, 1934. We also propose to print some extracts from the report by Messieurs Benezit and Renaud.

VERTICAL WALL BREAKWATERS.

By Signor Enrico Coen Cagli, Hon. Inspector General of Public Works, Professor of Maritime Engineering at the Engineering School, Rome. (Abridged.)

In 1905 in my report to the Tenth International Congress at Milan on the construction of outer moles in ports, I attached considerable importance to certain principles derived from research and experience acquired up to that date in Italy in regard to breakwaters of the vertical wall type. In connection with this form of construction I drew particular attention to the necessity: (i) of building the base of the vertical wall at the greatest depth compatible with practical construction of the wall under water; (ii) of giving to the wall as homogeneous and compact a structure as possible, like a monolith; and (iii) of so forming the rubble foundation that it could bear both the concentrated weight of the wall and the action of the motion of the sea without giving way or suffering sudden and unequal settling.

I pointed out that the system of construction by means of large monoliths frequently employed in the building of breakwaters abroad possessed serious drawbacks and that the design of monoliths for such purposes required to be improved with a view mainly to reducing the difficulty of constructing and setting the monoliths so as to give the latter a more homogeneous structure, in which there would be no material liable to deteriorate in salt water; and also so as to avoid the dangers which might easily result from the sudden application of such a great load on a rubble mound of too great height or one resting on a soft sea bed.

The drawbacks so foretold were not long in being confirmed by the accidents which happened shortly afterwards to several of these structures; accidents that must be attributed either to constructional defects or to defective profile and construction of the rubble mound, or the insufficient depth of the base of the wall, or, again, to excessive length of the monoliths used for the construction of the wall.

It was in pursuing our researches to overcome the drawbacks inherent in large monoliths that we, in Italy, a few years later, proposed for the building of massive breakwaters in deep water exposed to heavy seas a structure of adjoining and independent piers, 5 m. or 6 m. long (in the longitudinal direction of the work), each formed by the super-position of a certain number of cellular blocks of length equal to the thickness of the wall, and formed, after setting, into a single monolith by filling the wells with concrete. The horizontal joints between the blocks were to be filled with suitable packing, either of lead or vegetable fibre, in order to ensure the better bedding of each block on the lower one; and to make the joints watertight for the purpose of ensuring good results from the pouring of concrete into the wells and for reducing to a minimum upward hydraulic pressures, especially those of a dynamic character. This system was tested in 1910 in the building of the Granili breakwater at Naples, and was applied on a large scale in the construction of the breakwater sheltering the Vittorio Emanuele basin, and the lengthening of the Galliera mole at Genoa, in both of which the vertical wall comprises a single row of piers, each pier being formed by superposing three cellular blocks having an individual weight of 220 tons. This first large-scale application of the new type of breakwater structure was not long in showing some drawbacks, all depending on the large internal voids. Blocks were exposed, before being filled, to the risk of serious damage by waves, and the pouring of concrete into the cells of large dimensions did not give entirely satisfactory results. It was found that the relatively thin walls were liable to fracture under the action of excessive stress. These circumstances led us towards the end of 1922 to consider the possibility, thanks to the improvements made in the building of floating lifting plant, of

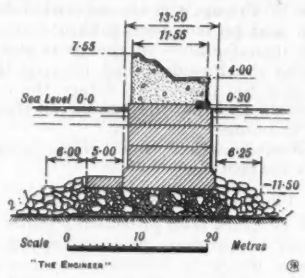


FIG. 2—PRINCIPE UMBERTO MOLE BETWEEN 2315 M. AND BREAKWATER HEAD

and Benghazi. A summary description of all these works is contained in the report presented by the author in collaboration with Signor A. Albertazzi to the Fourteenth Navigation Congress at Cairo.* It was not long before all these works provided unexpected results. In Italy we were clear as to the fundamental rules to be followed in building a rubble base and the main structure, but experience was lacking as to the requisite depth for the base of the vertical wall and as to the profile for the berm and the inclination of the slope of the rubble mound on its outer face. We assumed that by placing the foot of the vertical wall at a depth of about 10 m. danger of breaking waves would be avoided. We did not know either the maximum intensity of wave pressure or the law of variation at various levels. We reckoned, however, that a width of 12 m. for the wall structure would be sufficient, even in the most exposed parts of the Mediterranean Sea, to ensure the required stability.

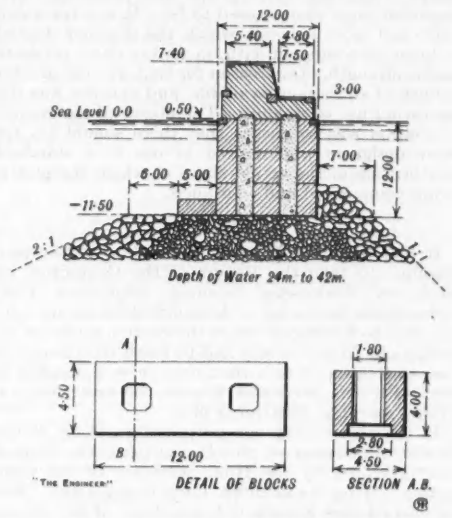


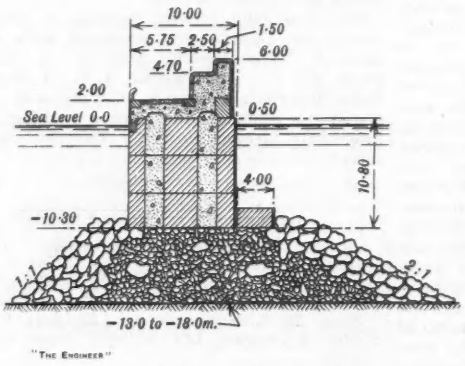
FIG. 3—NEW JETTY: SOUTHERN ENTRANCE TO NAPLES HARBOUR

It was in view of these uncertainties that, following the Fourteenth International Navigation Congress in December, 1926, an international committee of experts was appointed to study the stresses due to waves on breakwater structures and the instruments most suitable for their measurement, making a distinction between the case of a wave having an orbital movement and that of breaking waves.

EXPERIENCE IN ITALY SINCE 1926.

Since 1926 the type of breakwater having a vertical wall has been adopted for many new works in Italian ports. This policy has afforded a wide field of experience and has also given rise to observations and research which have led to remarkable results. The works carried out have given, up to now, generally satisfactory results, with the exception of the new mole at the port of Catania, which unfortunately met with disaster.

The cyclopean blocks which were used in the building of the Principe Umberto mole at Genoa, after the abandonment of cellular block construction in 1925,



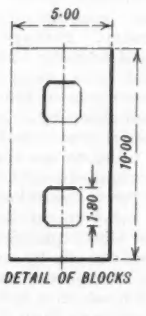


FIG. 4—MOLE AT BARI

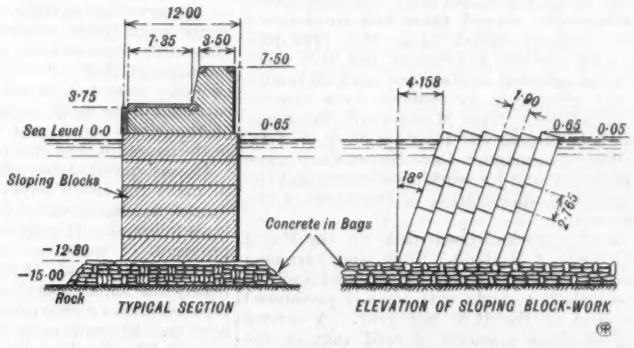


FIG. 5—OUTER MOLE AT BENGHAZI, N. AFRICA

solving the problem in a satisfactory manner by substituting, for the cellular blocks, cyclopean concrete blocks made with cores or hollows of dimensions sufficiently small to eliminate the various drawbacks ascertained by experience, but which would still provide the means for the connection of the units of each pier into a monolithic structure. Furthermore, it was expected, in the case of works in positions of moderate exposure, that it might even be possible to eliminate the necessity of cavities in the blocks, by using solid blocks of sufficient weight to give them individually the requisite resistance.

The system of cellular blocks was therefore abandoned and replaced by cyclopean block construction, both for the breakwaters then being built in the port of Genoa, and for those subsequently planned at other ports, including Naples, Catania, Palermo, Bari, measure 12 m. by 4 m. by 2·7 m., each having two circular wells of 2 m. diameter. These, however, did not prove altogether satisfactory, and it was also found that the concrete apron blocks protecting the outer toe of the vertical wall, founded at a level of −10·5 m., as well as the natural stone blocks forming the berm and outer slope of the rubble mound, were frequently displaced. These results led the engineers in charge of the harbour works at Genoa, in building the last 1850 m. of the Principe Umberto mole, to replace the blocks having large cavities by solid blocks of an individual weight of from 300 to 330 tons, provided with four holes for the purpose of lifting; and, at the same time, to modify the profile of the work by lowering the foot of the wall to −11·5 m., giving its

* Report No. 36, "Breakwaters or Jetties in Tideless Seas."

base an additional width of 1·5 m., and by reducing the height of the apron blocks from 2 m. to 1·5 m., so as to increase the depth of water to their upper face from 8·5 m. to 10 m.—Fig. 1. Only the two upper blocks in each pier are joined together by means of four cavities filled with concrete. This degree of connection has the advantage of not preventing the possibility of the removal of the blocks in case of need; but that is an advantage which, in my opinion, is not comparable with that of total "monolithisation" of the piers such as is given by blocks provided with core holes or wells. Experience confirmed by tests made during the construction of the new breakwaters at Naples and Bari have supplied positive proof of the individual resistance of blocks formed with cores and of the good results obtained by filling the latter

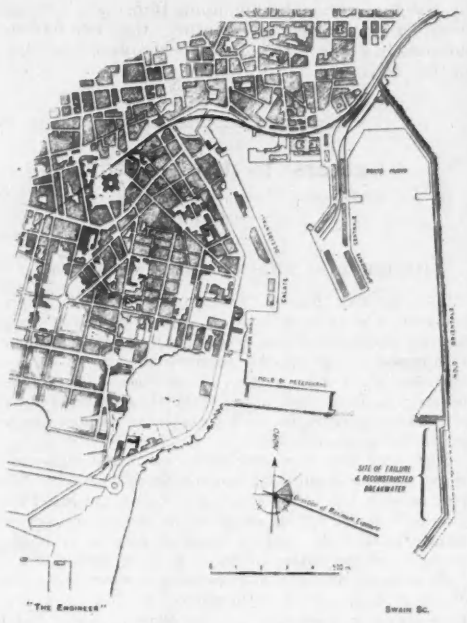


FIG. 6—PLAN OF CATANIA HARBOUR, SICILY

with concrete. These tests have, moreover, given proof of the almost absolute water-tightness that can be obtained in the horizontal joints between the blocks forming the piers by the use of suitable packing. It would even be possible to concrete the wells in the dry after having tamped the bottom by pouring under water a sufficient layer of concrete, thus obtaining a still more perfect "monolithisation" of all the piers.

The superstructure of the Principe Umberto mole was also altered for the last 1080 m. of the breakwater by adopting the profile shown in Fig. 2, the new profile being designed, on the one hand, to bring the centre of gravity of the mass concrete towards the medial line in order to lessen fatigue of the rubble base by the hammering action of the wall (notably along the outer toe) due to the effect of alternating

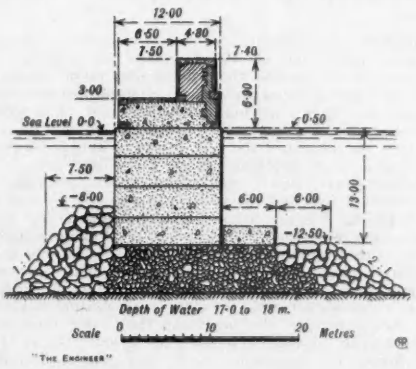


FIG. 7—CATANIA, EAST MOLE EXTENSION

vertical stresses; and, on the other hand, to increase the resistance of the mass concrete superstructure itself to torsional stresses arising from the variation in the distribution of horizontal pressures along the wall. The superstructure in this part of the mole was also built in the form of a continuous mass without expansion and contraction joints at intervals of two or three piers which had been provided in the older part of the work.

The same type of construction as that employed in the final section of the Principe Umberto mole has been adopted at Genoa in building two secondary breakwaters at the east and west ends of the port in positions of less exposure. In building the Umberto Cagni mole, where the sea bed consists of mud, excessive settlement of the rubble mound has been obviated by replacing the mud to a depth of 3 m. by clean sand before the deposit of the rubble stone to form the substructure.

In spite of the greater depth provided for the base of the vertical wall on the last 1850 m. of the Principe Umberto mole the condition of the apron blocks and the berm and seaward slope of the rubble mound, protected by large natural quarry stones, is still unsatisfactory. In order to increase the stability of this part of the work and to protect the wall from all danger of undermining, the berm at the face of the wall is now being increased in width to 15 m. and the seaward face slope of the mound is being flattened to 1 in 3.

The new jetty at the entrance to the port of Naples—Fig. 3—has been built of cyclopean blocks (with core holes) which weigh 410 tons, founded at a depth of 11·5 m. This structure, exposed to less severe seas than the Principe Umberto mole at Genoa, but built in depths ranging from 24 m. to 42 m., has so far shown no signs of weakness.

At Bari the new outer breakwater—Fig. 4—2400 m. long, in depths ranging from 13 m. to 18 m., has a vertical wall founded at a level of −10·3 m., the cored cyclopean blocks weighing 320 tons. The wall has proved satisfactory, but trouble has been experienced with the apron and rubble mound. Apron blocks measuring 4 m. by 2 m. by 2 m. on the seaward berm and the stones forming the slope of the rubble mound on its outer face have not proved sufficiently stable in storms with waves 4 m. high in the offing. It has therefore been decided, as at Genoa, to increase considerably the width of the berm and to flatten the seaward slope of the rubble mound.

For the outer breakwater of the new Italian port at Benghazi, in North Africa, of which the main arm is about 1000 m. long in a depth of 13 m. to 14 m., the type of structure shown in Fig. 5 has been adopted. Here the sea bed is of a rocky nature covered by a thin layer of sand. The foundation consists of a layer of concrete in bags deposited on the rock bottom, previously cleared of sand by a suction dredger. The vertical wall consists of sliced blockwork; each block weighs 130 tons and stretches across the full width of the wall, 12 m. The wall is surmounted by a mass concrete capping and parapet. The blocks are dowelled together by means of reinforced concrete keys, or by concrete sausages in bags, inserted in grooves formed in the faces of adjoining blocks.

THE FAILURE OF THE CATANIA MOLE.

At Catania, on the East Coast of Sicily, where the new extension of the east mole is exposed to very heavy storms from east-south-east—see plan Fig. 6—the original intention was to construct the vertical wall of the mole of cyclopean blocks with cored holes. This plan was, however, abandoned, and solid blocks, measuring 12 m. by 4 m. by 3·25 m., each weighing 320 tons, were employed—Fig. 7. No provision was made for the packing of the horizontal joints of the piers. It was expected that waves of a maximum height of 7 m. and a length of 150 m. would be experienced and the base of the vertical wall was therefore placed as low as −12·5 m. The rubble mound rested on a sea bed of compact sand, the seaward berm being 12 m. wide and protected by apron blocks. On the inside face of the wall the toe was buttressed by large rubble stones brought up to the level −8·0 m. The substructure of the vertical wall, consisting of four layers of blocks, had already been built to a length of about 650 m., comprising the whole of the first arm and 150 m. of the second arm; and the superstructure had been completed for a distance of about 300 m. from the root, when, on February 21st, 1930, a storm of exceptional violence, characterised by a total absence of wind and waves 7 m. high and 200 m. long in the open sea, caused considerable damage to the work. The blocks forming the wall had to a large extent slipped towards the harbour, sliding one on top of another. This displacement amounted to a few centimetres

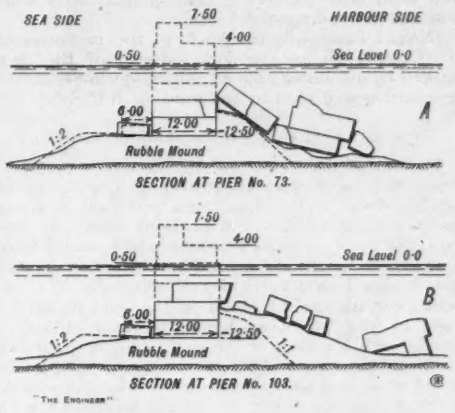


FIG. 8—DIAGRAMS SHOWING COLLAPSE OF CATANIA MOLE

only in that part of the work where the capping and parapet had been completed. Further out the displacement was much greater, some of the blocks being thrown into the harbour. Only the foundation blocks resting on the rubble mound and buttressed by the stone backing remained in place almost intact. Of the blocks forming the other layers a very high percentage had been broken or split. The rubble mound had also settled to some extent, causing the wall to tilt slightly in places. This damage, which two later storms in November, 1930, and February, 1931,

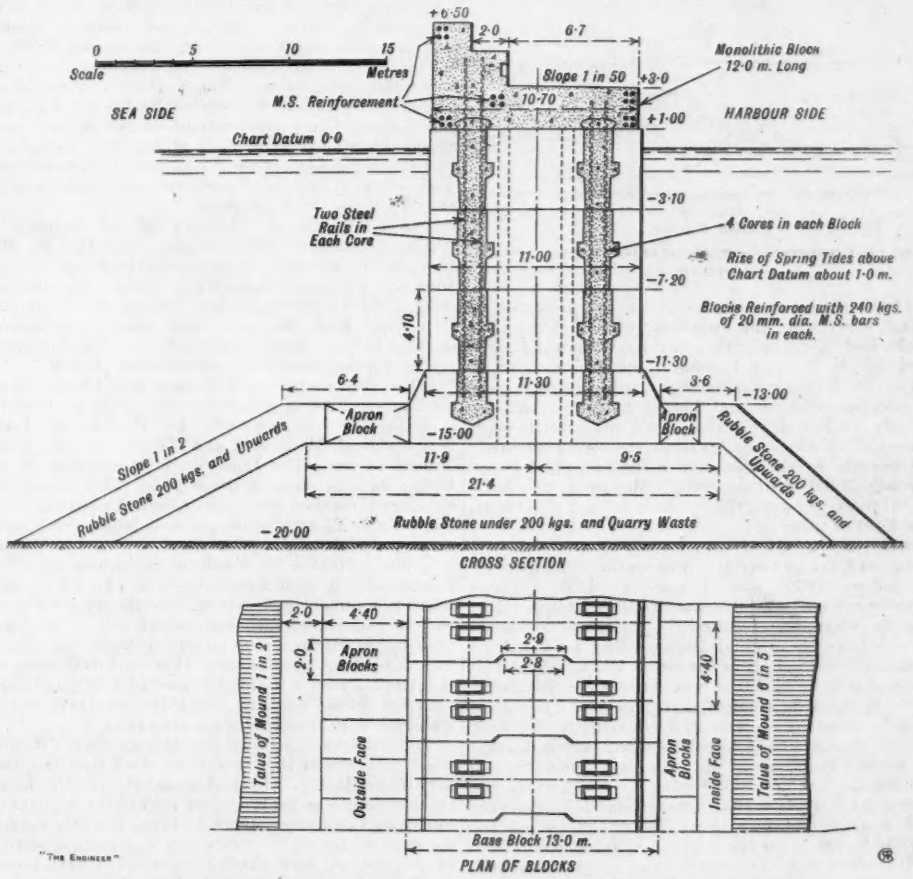


FIG. 9—MUSTAPHA JETTY ALGIERS: SECTION AND PLAN OF OUTER ARM

had slightly increased, was repaired without any change in the profile of the work except for the raising of the mass concrete capping from a level of 3 m. to 4 m. with a view to increasing the load of the wall structure. The base of the vertical wall of the second arm was also lowered to −13·5 m. The rebuilding of the first arm of the jetty had been completed when, on March 26th, 1933, the mole was exposed to a storm of still greater violence than those previously recorded and the structure was almost completely demolished. On this occasion waves 7·5 m. high and 230 m. long in the open sea were experienced. The wind velocity, however, was comparatively low (40 kiloms. per hour), but it is said by observers that waves broke in

front of the wall. All the blocks of the two upper layers and a number of those forming the layer beneath, seaward of that part of the mole which is buttressed by an embankment—see plan, Fig. 6—slipped one over the other towards the harbour and, together with the superstructure, tumbled into a heap of ruins—Fig. 8.† The berm and outer slope of the rubble base, that had remained almost intact on the portion of the mole that was not ruined, suffered, over the remaining length of the structure, considerable damage, and the sea bed at the foot of the work had been slightly undermined. Most of the apron blocks had, however, remained in place or had been only slightly displaced, and the rubble beneath the wall remained intact.

[NOTE: Practically the whole of the two arms of the Catania Mole extension, seaward of the part backed by an embankment, collapsed: not only the first arm as indicated by the wording in Fig. 6.]

FAILURE OF THE MUSTAPHA JETTY, ALGIERS.‡

The Mustapha Jetty at Algiers consists of two arms, the outer arm, about 600 m. long, being in depths of water exceeding 20 m. and built on a sea bed consisting of fine and unstable sand. It was expected to be exposed to waves which would have a maximum height of 5 m. and a length of 80 m., and was designed as a vertical wall, generally 11 m. in width, but increased to 13 m. at the base, formed of piers of four cyclopean blocks of about 400 tons weight each, the base of the wall being at −15·0 m. on a rubble mound. This mound consisted of rough rubble stone and quarry waste covered by a layer 3 m. thick of quarried stones of over 200 kilos. each, with apron blocks, measuring 4·4 m. by 2 m. by 2 m., laid as headers on the outer face and as stretchers on the inner berm of the mound. The berm width on the seaward side was 6·4 m. The wall blocks each

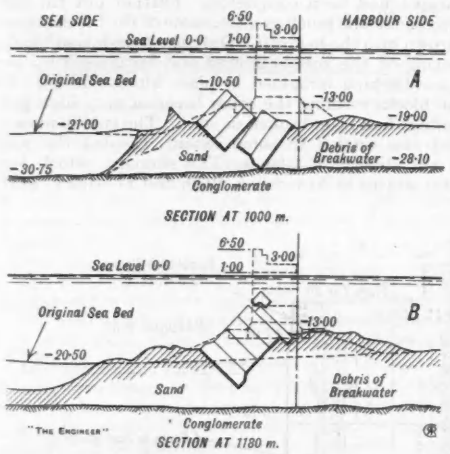


FIG. 10—CONDITION OF MUSTAPHA JETTY AFTER STORM

had four small cores of rectangular section for use in lifting, which were also intended to be filled after the blocks had been set, with concrete reinforced by old steel rails, with a view to making the piers monolithic—Fig. 9. In carrying out the work, however, this connection between the blocks had been almost entirely neglected, the cores being filled with rough stone and quarry waste, except the two cores near the outside in the two upper blocks, which were partially filled with concrete. Moreover, the horizontal joints between the blocks were not filled with any kind of packing.§

Some damage occurred to the work whilst it was being built by two storms of exceptional violence in December, 1930, and December, 1931. These occurrences and the disaster to the Catania mole, already referred to, induced the engineers at Algiers to revert to the original design, which provided for monolithic piers, and in the whole of the work then remaining to be built the cores or wells in the blocks were filled with reinforced concrete. The work already constructed was strengthened by injecting cement mortar into the rubble filled core holes and by similar injections in the horizontal joints between the blocks. All blocks broken or cracked by the storms of 1930 and 1931 were repaired by grouting and heavy steel bars were embedded in all the bore-holes made for the purpose of injections.

This work of consolidation was well advanced and, in addition, the work of sealing with bitumen and cement the vertical joints between the piers in the last 500 m. of the jetty was about to be begun, when, on February 2nd, 1934, there occurred a storm of extraordinary violence characterised by a total absence of wind and by rollers having a wave length of 300 m. and heights up to 9 m. in the open sea. The outer arm of the jetty was exposed to the full force of this storm and waves struck the vertical wall on a line at about right angles to its length. A slight general lowering of the level of the wall was observed during the day, and in the early morning of February 3rd the outer 400 m. of the arm, with the exception of the jetty head, suddenly overturned towards the offing.

Subsequent examination showed clearly that the wall had collapsed owing to the giving way of the rubble mound, which, after progressively settling under the incessant and violent hammering of the superimposed wall, had suddenly slid into a deep hollow, in places 10 m. deep, scoured by the swell in the easily erodable sea bed—Fig. 10.‖ The Mustapha Jetty would have survived the huge seas of February, 1934, if the rubble mound had not been undermined and degraded; and, moreover, even if the vertical wall had been subjected to some extent to the force of breaking waves it might still have survived, if not whole certainly with much less serious damage, if the system of reinforcing the structure by sealing all the horizontal and vertical joints had been extended to the second arm as a whole, and had the rubble mound remained substantially intact and effective. Furthermore, if the Catania mole, with a width of 12 m. and founded on a relatively stable base, had had the same monolithic nature as the Mustapha Jetty it would have been able to offer the necessary resistance to the formidable attack of the storm on March 26th, 1933, or, at any rate, to have emerged from that trial without irreparable damage.

(To be continued.)

† This diagram is reproduced by the courtesy of Signor Cagli from an article by him in "Annali dei Lavori Pubblici, 1934," p. 516.

‡ The Mustapha Jetty is described in an illustrated article in THE ENGINEER, May 11th, 1934.

§ We reproduce Fig. 9 from the description of the Mustapha Jetty in our issue of May 11th, 1934. This shows (as does the drawing contained in Signor Cagli's report) the original design.

‖ Fig. 10 is reproduced from Signor Cagli's article in "Annali dei Lavori Pubblici," to which reference has already been made.

Institute of Metals.

No. I.

THE Institute of Metals has been holding its twenty-seventh Annual Autumn Meeting this week at Newcastle-on-Tyne, under the presidency of Dr. Harold Moore, the Director of the British Non-Ferrous Metals Research Association. Twenty-four years have elapsed since the parent Institute held a meeting in the city—a fact which was commented on by the Acting Lord Mayor when according the Institute a welcome.

There was, as usual, so large a programme of papers that there was not time to discuss them all. Arrangements were made for visits to works (alternative visits were arranged for the ladies), there was a civic reception and dance, a dinner, and finally, a whole-day excursion to Borcovicus and the Roman Wall.

The proceedings opened on Monday evening, September 9th, in the King's Hall at Armstrong College, when Dr. J. T. Batey (the President of the North-East Coast Institution of Engineers and Shipbuilders, and a member of the local Reception Committee) deputised for Sir Charles Craven (Chairman of the Reception Committee), and extended to the members a hearty welcome.

There followed the delivery of the fourteenth Autumn Lecture. The lecturer was Dr. H. W. Brownsdon (research manager of the metal group, Imperial Chemical Industries, Ltd.), the subject being Metal Melting: Its Effect on Quality." Departing from custom, there was a discussion on this lecture, which we shall report in our next issue. The lecture itself is reprinted on page 277.

When the members assembled at Armstrong College on Tuesday morning, September 10th, they were accorded a civic reception by the Acting Lord Mayor, Dr. J. W. Leech, and the Sheriff, Alderman Gilbert Oliver. The Lord Mayor, Councillor R. S. Dalgliesh, was away in Manchester. Dr. Leech, in his speech, recalled the work of Lord Armstrong, who started the Elswick works, which had at one time employed 25,000 men, whereas to-day they employed only about 3000 as the result of the depression. The people, he said, looked to research men for a lead, and asked them to delve deep down into Nature for secrets with which to create new industries and improve those existing in the interests of the country generally. The Sheriff also emphasised that the well-being of the British people generally was very largely associated with the work to which the members of the Institute were directing their attention.

The President, in returning thanks to the Acting Lord Mayor and the Sheriff, recalled that the late Sir Gerard Muntz, who had presided over the Institute's meeting in 1911, had referred to the Institute's Corrosion Committee, which had then recently started its work on condenser tubes—so important a feature in connection with marine engineering and power production. The progress which had been made since that time in regard to condenser tubes, said Dr. Moore, owed a good deal to the work of the Corrosion Committee. He also recalled that the late Sir Charles Parsons, who had played so prominent a part in the industrial life of the North-East Coast particularly, was a member of Council of the Institute for many years.

The President extended a hearty welcome to the following overseas members of the Institute attending the meeting:—Mr. P. G. Bamford (New Zealand), Mr. H. N. Bassett (Hon. Corresponding Member to the Council for Egypt), Herr L. Edens (Angewandte Chemie, Berlin), Dr. M. Hansen (Germany), Dr. Lepp (Holland), Dr. W. J. P. Rohn (Germany), and Dr. P. Rosbaud (Germany).

The Council's nominations for election to the Council for 1936 were announced as follows:—

President: Mr. W. R. Barclay. Vice-Presidents: Professor D. Hanson, Mr. E. L. Morcom. Members of Council: Professor J. H. Andrew, Dr. S. F. Dorey, Mr. Kenneth Gray, Lieut.-Colonel J. H. M. Greenly, Mr. H. H. A. Greer, Dr. J. L. Haughton, Mr. D. J. Macnaughton, Dr. C. J. Smithells, Mr. F. Tomlinson.

The result of the ballot will be declared at the annual meeting in London in March, 1936.

The annual meeting of the Institute will be held in London on March 11th and 12th, 1936. The Council has accepted an invitation from friends of the Institute in Paris—the lead having been taken by the International Aluminium Bureau, associated with other bodies representing the non-ferrous interests in France—to hold the next autumn meeting in that city.

(To be continued.)

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

HIGH-SPEED TRAINS AND VIBRATION.

SIR,—In THE ENGINEER for July 5th, 1935, there appeared a letter from Mr. C. F. Dendy Marshall raising the very pertinent subject—the relation of the track gauge with regard to high speeds—terminating with the suggestion that the flanges of tires of carriage wheels should be rearranged in such a way that their working faces allowed less play within a track exactly to standard gauge than is the present custom.

I consider there is a very great deal in the suggestion made that for high-speed running there should be less play between the wheel flanges and the rail gauge. This, however, should not be obtained by the adjustment of flanges, because the existing flange distances are properly arranged for negotiating curves, cross-overs, sidings, &c.

On railways abroad it is customary to widen the gauge considerably on curves for the purpose of allowing locomotives with long wheel bases relative thereto to pass, but I am not aware whether this is done to any considerable extent on the home railways. The logical thing to do would appear to be to close in the distance between the rails on straight portions of track—and, of course, proportionately so on nominal curves—so that the existing horizontal distances between the common tangents of the root of the flange and the shoulder of the rail top, which is $\frac{5}{16}$in. each side, equal to $\frac{5}{8}$in. total, according to the B.E.S.A. report of 1927, to a lesser allowance, leaving all other existing circumstances of track gauge and flange positions as they are; it is presumed that the maintenance of the track can be satisfactorily arranged with a lesser margin than $\frac{1}{8}$in. without danger arising from "gauge too tight."

P. C. DEWHURST.

Montevideo, August, 1935.

A Visit to a Transformer Works.

MODERN requirements of the electricity supply industry have led to developments in transformer construction far beyond the wildest dreams of electrical pioneers. Accumulated experience and improved materials resulted in the production of transformers of steadily increasing size leaving little or nothing to be desired. But with the advent of the grid designers were faced with new and difficult problems calling for a departure from orthodox ideas. Units with outputs much in excess of those built before and for voltages up to 132 kV had to be produced. The manner in which the demand has been met speaks well for the designing and manufacturing ability of those entrusted with the work. Design has been influenced in many cases by the transport which governs the permissible size. But perhaps the ability of British electrical manufacturers to meet new requirements is best exemplified by the ingenuity they have displayed in producing on-load tap-changing gear. Before the grid began to materialise such gear was practically unknown in this country. Induction regulators and separate booster transformers were generally used for voltage regulation; the on-load tap-changing scheme being largely the outcome of a demand for a cheaper method. Readers of THE ENGINEER have been kept in touch with what has been done in this connection by British transformer manufacturers. With perhaps one or two exceptions all new gear produced has been described as well as other modern transformer developments, such as multiple-winding units for giving several voltages.

Firms that were engaged in transformer manufacture in the early days of electrical engineering can look back on steady and important progress which, from time to time, has necessitated the provision of new and much heavier plant. Of these firms, the British Electric Transformer Company, Ltd., Hayes, Middlesex, whose works we have recently visited, is one of the best known. Its workshops are confined to the manufacture of transformers and kindred apparatus, such as reactors and static boosters, including the new capacity booster described in our issue of March 1st of this year. The company was established in 1898 for the manufacture of transformers covered by the patents of Mr. A. F. Berry. Originally the works were at Bow, but they were subsequently transferred to Farringdon-road. The Hayes works, with which we are here concerned, were erected

in 1901, and have been actively engaged on the production of transformers ever since, necessitating many additions. With the association of the company with Crompton Parkinson, Ltd., in 1932, the design, manufacturing, and sales organisations of the two concerns were combined. All sizes and types of transformers are now made, ranging from the smallest instrument transformers to the largest that can be transported. Although Mr. A. F. Berry introduced his transformer as far back as 1898, many modern radial transformers, as shown in Figs 1 and 2, are made. Many single and three-phase radial units, which are particularly silent in operation and are claimed to offer other advantages under certain conditions, were in evidence in the works last week, together with many others of other types for service in this country and abroad. There were three-phase and single-phase core and shell units in many sizes for indoor and outdoor use; furnace and mining transformers; reactors and hermetically sealed units for use in damp and other situations in which unfavourable operating conditions prevail. Apart from manufacturing the tanks, practically all the operations involved in transformer construction are carried out at the Hayes works, including that of covering the conductors with paper and cotton on machines shown in Figs. 3 and 4 respectively.

Four types of windings are used on large-core type transformers—spiral, sectional, continuous disc, and wedge windings. In the latter wedge-shaped pieces of insulation are inserted between the layers so that the thick end is at the point of the maximum difference of potential between the layers. On all windings adjustable-pressure screws are provided at the top of the coils and engage with a stout steel clamping ring which can withstand the maximum forces imposed under short-circuit conditions. After stoving and while the transformers are hot, the clamps are tightened and require no further attention beyond an occasional testing of the lock nuts. When tappings are called for, care is taken to preserve as far as possible the magnetic balance and to relieve them of strain due to external short circuits. Tapping leads are made as short as possible.

As a rule the low-voltage winding is, of course, next to the core, and the cylinder on which it is wound fits the core leg tightly, but additional security is derived from dried and impregnated teak wedges, driven the whole length of the foundation cylinder. By means of the duct spacers all subsequent windings are made a tight fit on the previous windings.

Small and medium-sized core-type units have spiral, former or disc windings, and like those of all other transformers, are given a preliminary heating before they are thoroughly vacuum dried and impregnated with oil. The end turns of all high-tension windings are usually insulated in excess of the requirements of the B.S.S. 422 of 1927. While some transformer makers advocate oil-filled bushings and others condenser bushings, the B.E.T. Company uses both. All the company's transformers are carefully dried out before despatch. The moisture is completely extracted from the coils by the application of a high vacuum, and whilst under it they are completely submerged in dry, hot oil, which is subsequently driven out by air pressure, when a final heating is given. After complete assembly of the coils on the core, the whole transformer is placed in a hot oven with dry air circulated through it, and is left there until the insulation resistance indicates that the final drying is complete, when the transformer is immediately immersed in dry oil, in which it remains.

Two systems of tap changing are applied to B.E.T. transformers, the Crompton Weaving gear, described in our issue of November 25th, 1932, and the company's standard automatic régulating gear, described in its original form in THE ENGINEER of August 2nd, 1929. The Crompton Weaving gear, it will be remembered, reduces the break voltage and thus the severity of the duty to within the capacity of ordinary selector switches without mechanical complications. Tendencies for arcing to occur are minimised by a patented system of transformers which takes the place of the ordinary mid-point auto transformers. Diagrams of connections and vector diagrams explaining the principle are to be found in the issue of THE ENGINEER mentioned. The scheme permits the use of a practically standard design of drum controller, free from the complications of quick-acting diverter switches and their auxiliary timing devices.

The B.E.T. capacity booster described in THE ENGINEER of March 1st has two main advantages—absence of moving parts and instantaneous and silent operation. At no load the losses are nil, whilst at full load they are less than that of a transformer of the same output. Its rapid action resulting from the absence of relays and switchgear enables the booster to deal with voltage variations of a transient nature, as when motors which are frequently started and stopped form part of a mixed load.

The company's share of orders for the British grid represented a total transformer capacity of over 2 million kVA. Since completion of the grid, orders for exceptionally large transformers for use in this country have naturally diminished, but a 10,000 kVA unit (shown on page 268), ordered by the Central Electricity Board, is at present nearing completion. The controller for the tap-changing gear is to be seen on the bracket bolted to the left-hand side of the tank, and through a vertical chain it drives the tapping switches situated inside the tank, the diverter switches, equipped with mechanical lowering gear, being on the front of the tank. The unit is entirely self-contained and is being supplied as a spare unit for use on the grid system. Three 8000 kVA transformers in the course of construction form part of an order for seven single-phase units for the New Zealand Public Works Department for use on the New Zealand grid at Arapuni. The units, shown on page 268, are to

FIG. 1—GROUP OF RADIAL TRANSFORMERS

FIG. 2—WINDING A RADIAL TRANSFORMER

FIG. 3—COVERING CONDUCTORS WITH PAPER INSULATION

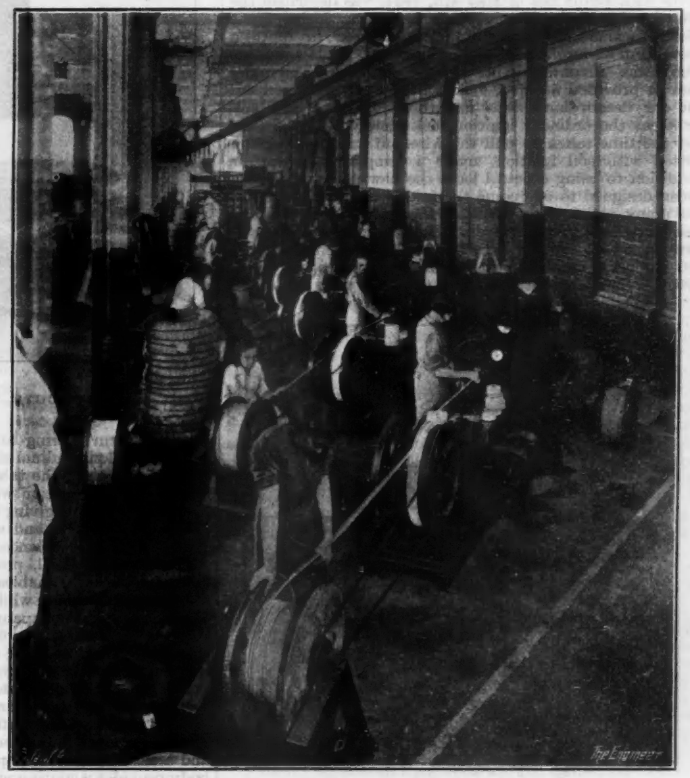


FIG. 4—COVERING CONDUCTORS WITH COTTON

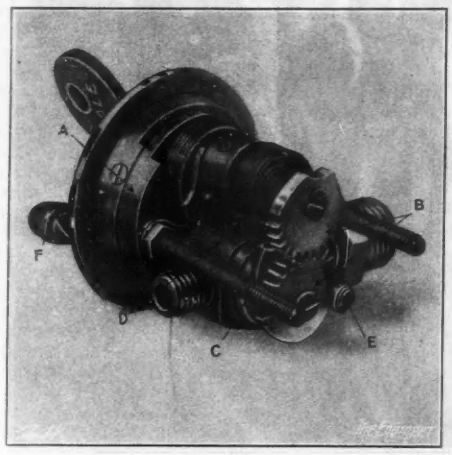
be coupled in two banks of three with one as a spare, the ratio being 11,000/63,500 volts.

Needless to say, testing equipment forms an important part of the works. There is a main test-house, a routine test-house, and an instrument transformer test-house adjoining. The first comprises a motor generator house, a ground level testing department for transformers up to 6000 kVA, and a testing gallery with measuring tables and machine controls for testing the larger transformers. Power is obtained from a 2000 kVA transformer, giving supplies at 20,000, 6000, 3300, or 440 volts. There are five motor generator sets, giving a frequency range of 12 to 66 cycles, a high-frequency range from 100 to 200 cycles, and three and single-phase pressures up to 40,000 volts with the aid of transformers. Two large motor generator sets are driven by synchronous motors, one having a 25-cycle generator of 4000 kVA for providing circulating current for temperature runs on large transformers. The other large machine is capable of inversion. It gives a fixed frequency of 100 cycles at 1200 kVA, and 0 to 40,000 volts for over-potential testing, or at 25 cycles, 600 kVA for three-phase loading. Temperature runs can be made on two 45,000 kVA, 10 per cent. impedance transformers connected back to back, or on two 60,000 kVA, 6 per cent. impedance units. A delta-delta test can be made on one three-phase, 60,000 kVA, 10 per cent. impedance transformer. High-pressure tests can be made up to 300,000 volts. Losses are measured either by the two or three wattmeter method. Form factor meters give the average in addition to the R.M.S. value of the voltage or iron loss tests, thus ensuring that inaccuracies due to bad wave form of the applied voltage are taken into account. For surge testing a surge generator, giving a pressure of 380,000 volts, and an instantaneous discharge of 100,000 kVA, is used.

In the routine test-house voltage ratio is measured by a resistance ratiometer with an accuracy greater than that required by the B.S.I. specification. A motor generator set with an output of 300 kVA gives a frequency variation from 25 to 60 cycles, and single or three-phase pressures from 0 to 11,000 volts. Another set of 75 kVA is provided for over-potential testing. Adjoining the routine test-house is the instrument transformer test-house, containing "shotter" apparatus for tests of ratio and phase angle errors to all specifications up to precision accuracy on both potential and current transformers. For current transformer testing a maximum current of 300 ampères can be obtained, and pressures up to 33,000 volts for testing single and three-phase potential transformers.

The Featherstone Motor Car Lock.

IN THE ENGINEER of May 4th, 1934, was described the first model of the Featherstone motor car lock. Since then various improvements have resulted in quite a new form of mechanism which, however, while retaining the same advantages, has others besides. The older design provided a petrol lock which, as was pointed out in our description, stops unauthorised use of the car, whereas the ordinary ignition lock merely delays a thief by the time taken to pull the wires off and, if the car is fitted with coil ignition, make a temporary joint. In addition to being a petrol lock, the new pattern lock has been designed to overcome the fault which often nullifies so many precautions, namely, the unfortunate habit of leaving the key in the lock. By overcoming this habit we learn that the Featherstone lock has been granted a 10 per cent. rebate on the insurance policies of cars so fitted. The illustration shows the lock with its casing

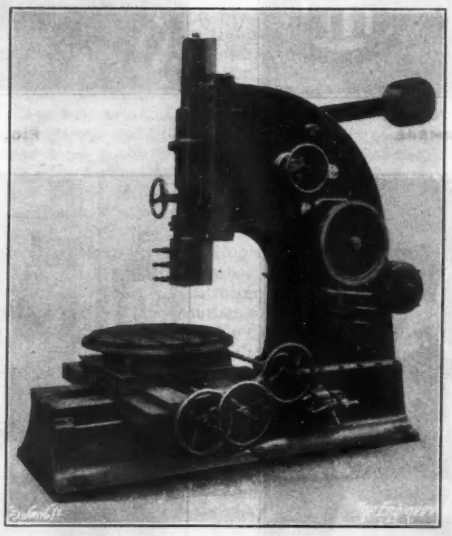


FEATHERSTONE MOTOR CAR LOCK

removed. Its size will be gauged from that of the standard Yale key. Assuming the car to be locked the operation of unlocking it consists of inserting the key and turning it clockwise. Inserting the key raises the upper end of the rocker lever A, which has been locking the barrel of the Yale lock, and which at its lower end now locks the lower shaft of the lock. The rotation of the key is transmitted through the Yale lock to the pinion train B, which drives round the collar C on the lower shaft. This collar C is locked to the barrel of the petrol cock D, which is moved to the "open" position. The ignition switch forms part of the end cover of the lock, and consists of two contacts which are closed by the knob E when it is in the "on" position. The car is now in running order with petrol and ignition "on." To stop the engine in this position necessitates the removal of the key, as it will be seen that to turn the key and, therefore, the pinions B back has no effect on the collar C and, therefore, on the locking devices. These have now to be brought to the "off" position by the handle F. This, however, is locked by the lever A until the removal of the key allows the lever A to drop clear. Having removed the key the handle F is turned. This rotates the collar C through the spindle of the petrol cock itself D, bringing it to the "off" position and releasing the ignition contacts at the same time. The handle F actuates the cock spindle by means of a pin working against a tooth on the shaft. When the "off" position is attained, the tooth is in such a position that the handle F must be rotated right round to a vertically upwards position to engage it, a position which cannot be attained partly owing to various projections on the face of the lock which foul the lever, partly owing to the excentric mounting of the lever itself. Thus in the "off" position the lever is completely useless and "hangs free" on its spindle. To open the lock without the key the cover must be removed as in the illustration. To do this either the pipe unions of the petrol cock must be taken off, or the handle F must be removed from its spindle, and the whole lock drawn forwards off the petrol cock and out of its casing, either operation rather too big a job for the potential thief. The removal of the handle is deliberately discouraged by the position of the screw shown, which would normally be masked by the dashboard, while the removal of the cover from behind the dashboard involves an intimacy with the details of both car and lock more than is likely to belong to the average car thief. In conclusion, we would point out the great advantage of this device as a precaution against fire, in that to stop the engine the petrol must be turned off, and in car parks at race meetings, &c., the regulations are automatically obeyed.

A Heavy Duty Slotting Machine.

THE new heavy duty 20in. stroke slotting machine, made by Ormerod Shapers, Ltd., Hebden Bridge, which is illustrated herewith, has been designed to meet the demand for an easily controlled high-speed heavy duty tool of this class. The control positions of all the movements and the speed and feed changes are grouped within easy reach of the operator in his ordinary position. Work 6ft. in diameter and 2ft. 3in. in height can be admitted. The table is of the compound circular type and has easily dis-



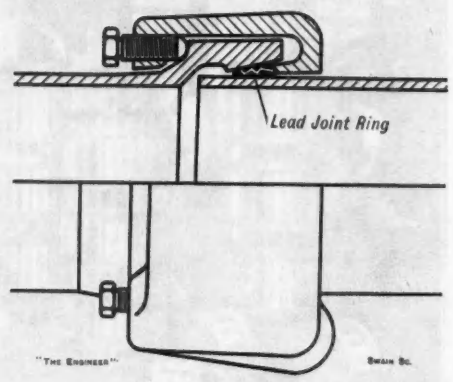
HEAVY DUTY SLOTTING MACHINE

engaged worm gearing to allow the rapid setting of the work. The longitudinal and transverse traverses and the circular motion of the table may be actuated by hand or by a self-acting motion with a friction control through a reversible feed box giving five rates of feed. The ram has chilled sliding faces and runs in vee guides, 4ft. long by 11in. wide. It is balanced by a counterweight. A large diameter hand wheel, projecting from the centre of the main driving hub, enables the stroke to be adjusted from zero to the maximum whilst the machine is in motion and eliminates the use of spanners. There are nine changes of speed to the ram, giving 6 to 40 strokes per minute. The gear-box is built as a unit and is housed inside the body of the machine. The changes of speed are obtained through two levers. The gear wheels are of nickel-chrome steel, heat treated, and are generated from the solid and mounted on solid multi-splined shafts. The drive from the gear-box to the ram is made by means of large double driving gears and a closed-end link. A pump mounted in a sump in the body provides a continuous flow of oil to the bearings, link motion, gear-box, and driving gears. The machine is driven either by means of a single pulley mounted on a friction clutch or by an independent motor drive through vee ropes. The floor space occupied by the machine is 11ft. by 7ft. 6in., the working height is 11ft. 6in., and the approximate weight 6½ tons. Fifteen h.p. is required to drive the machine at its maximum capacity.

Mechanical Lead Joint for Cast Iron Pipes.

THE increasing use of mechanical pipe joints is a notable feature of modern waterworks and gasworks practice, and points to the more exacting conditions under which mains are now required to operate. So far as cast iron pipes are concerned, engineers have shown some reluctance to depart from the traditional lead joints which have rendered efficient service for periods extending in some cases to well over a century. On the other hand, although lead is an excellent jointing material, the mechanical efficiency of the open socket lead joint leaves something to be desired as a result of the increased degree of traffic vibration to which mains are now subjected.

The Stanton mechanical lead joint, illustrated herewith, has been designed and introduced by the Stanton Ironworks Company, Ltd., near Nottingham, with the object of providing a lead joint which requires no lead running or caulking, which can be easily assembled under adverse conditions, and in which the jointing material is mechanically held in position. A pre-cast lead ring is compressed between two cast iron half-collars into a machined taper recess, in which position it is securely held by the half-collars. These collars completely encircle the socket and are tightened by four high-tensile cast iron setscrews, which are so placed that uniform pressure is applied to the lead ring. Inside the ring is cast a corrugated tapered spring insertion ring, which distributes the end pressure evenly. The lead joint ring is thereby made effective throughout its full depth, and not only over the outer portion, as occurs with the lead in a caulked joint. Although this joint is not offered as a flexible coupling intended for mains subject to severe ground subsidence or heavy traffic vibration, the manufacturers claim that it will withstand



LEAD JOINT FOR CAST IRON PIPE

a moderate amount of vibration more effectively than a caulked lead joint, and that it will permit without leakage angular distortion and "draw" of the spigot. Under test, it is stated, a short pipe line consisting of five 6in. diameter spun iron pipes, held an internal air pressure of 60 lb. per square inch for over ten months. In another test the same air pressure was maintained whilst one pipe was deflected and straightened to a degree equivalent to a 6in. side movement at the end of a pipe 6 yards long. In neither test, we are informed, was the slightest trace of leakage apparent.

LIQUID GAS.

ON Saturday last, the first national demonstration of "Calor-gas" was opened in Leeds by the Lord Mayor, Alderman W. Hemingway. "Calor-gas" is, we understand, a by-product of coal, a light hydro-carbon butane mixture in liquid form, supplied in convenient steel containers under a pressure of 1¼ atmospheres, each container, it is claimed, containing sufficient to supply "the needs of an average family of three people from six to ten weeks." It is not claimed to be a new invention, as the essential principle was known in 1828, but its use has not been exploited until recent years. To lay gas mains to remoter communities often presents difficulties which could be overcome by the use of "Calor-gas." It is proposed to arrange the supply of the gas to these remoter communities as well as to boat owners and similar users. In America "Calor-gas" has been in use for twenty years, we understand, while on the Continent it has been in use for two years.

WORLD LAND SPEED RECORDS.

ON Tuesday, September 3rd, the world's land speed record was raised by Sir Malcolm Campbell on his "Bluebird" motor car to a figure given as 301·1292 by the American Automobile Association. As is usual in these records, the final figures are meaningless. Nevertheless, they seem to have caused some confusion in calculation, as the first result was given as 299·875 m.p.h., which was later corrected to 301·177, and finally the figures were issued as: Time of first run, 11·83 sec., speed 304·311 m.p.h.; time of second run, 12·08 sec., speed 298·013 m.p.h. Average figures: Time, 11·955 sec., equivalent to 301·1292 m.p.h. On Sunday last, on the same course at Salt Lake City, Utah, Captain G. E. T. Eyston made five new world records. The figures given were 50 kilom. at 159·32 m.p.h., 50 miles at 160·38 m.p.h., 100 kilom. at 161·135 m.p.h., 100 miles at 159·597, and 200 kilom. at 158·552. The previous records had all been made by an American early last month on the same track, his best speed being given as 151·46 m.p.h. for the 200 kilom. record.

ON Tuesday, the 10th, an explosion and fire took place at the North Metropolitan Power Company's generating station at Brimsdown, near Enfield. The electrical supply was interrupted for periods varying from fifteen to seventy minutes at Edmonton, Enfield, Ponders End, Tottenham, Wood Green, Palmer's Green, Harringay, New Southgate, Watford, and St. Albans. Tramway services, traffic lights, and the Cockfoster's extension of the Piccadilly Line ceased to function. The fire broke out in some oil-immersed switchgear, and several thousand gallons of oil caught fire. An emergency call to all firemen in the Enfield and Ponder's End districts was made, and chemical foam extinguishing apparatus was used. Nobody was injured.

Metal Melting—Its Effect on Quality.*

By H. W. BROWNSDON,* M.Sc., Ph.D., Member of Council.

IN preparing this lecture I have been relieved of many of the anxieties usually associated with such a task. The subject is the choice of others, and my treatment of it is based on notes which Professor R. S. Hutton kindly placed at my disposal. All that was left for me to do was to link up the matter provided for me into presentable form, and in so doing I have introduced a few ideas of my own. As you are aware, this lecture breaks with precedent and, under the veil of an Autumn Lecture, serves as an introduction to a discussion on the subject.

Metal melting is carried out under such widely different conditions that some limitation of these becomes necessary if a concise review of the subject is to be made. Metal may be melted in 100-ton lots in a reverberatory furnace or drop by drop from a rod, as in welding. In both cases similar fundamental principles are involved, but under widely different conditions of melting, and it is with principles, rather than conditions, that I propose to deal.

When considering metal melting and its bearing on quality, it will be helpful to have some clear idea as to what is meant by quality. Quality implies the possession of desired distinctive properties, and the extent to which these are dependent on the process of melting is mainly determined by the degree to which the composition of the metal or alloy can be controlled during melting. So far as the melting process is concerned, quality and composition may be taken as synonymous, not forgetting, of course, that the ultimate quality of the finished product is also dependent on the many operations subsequent to melting.

Of the many factors which may come into play during the melting of a metal or alloy, some of the more important are diagrammatically indicated in the sketch.

It will be at once realised that metal melting, from a quality point of view, is not simply a matter of increasing the temperature so as to attain the liquid state, but involves the prevention or causation of a number of reactions which lead to changes in composition. The crucible becomes a reaction vessel, and the control of composition a complicated, difficult, but, at the same time, deeply interesting and important problem.

Taking a broad view of the control of composition, first consideration must be given to the choice of suitable raw materials. These may become contaminated during melting by oxidation, furnace gases, material from the melting vessel, and reaction products. There may be loss by volatilisation, by gas removal, and through the skimmings. Special additions may be made, fluxes used, or treatment with gases, and melting under reduced pressure may be resorted to for the removal of undesirable constituents, introduced either through the raw materials or during the melting operation.

The factors influencing quality can be conveniently grouped under the headings of raw material, contamination, and refining during melting.

RAW MATERIALS.

Most of the commonly used virgin metals are available in a relatively pure condition, but danger from a quality point of view may easily be lurking in constituents present only in the smallest quantities. A purity of 99·99 per cent. is by no means a safeguard against trouble, unless it is known that the remaining 0·01 per cent. will not interfere with the quality of the metal or alloy. Instead of referring to the purity of a metal in terms of the maior constituent, it would be much more instructive and helpful to know what the 0·01 per cent. consists of and to define the purity of a metal in terms relating to the impurities present. There are perhaps good reasons for the usually adopted method: an expression such as 99·99 per cent. impresses immediately with a sense of high purity, and is a figure more easily arrived at than details of the remaining 0·01 per cent., which in some cases may not be available.

The usual methods of stating the analysis of a metal never refer to gaseous constituents, which are known to be present and a frequent cause of serious trouble when molten metal solidifies. It will be an important advance when a fuller knowledge of gaseous constituents becomes available. A purity of 99·999 per cent. might suffice to remove all anxiety from metallic impurities, but if the remaining 0·001 per cent., or even 0·0001 per cent., consists of gaseous impurities, some reflection on quality may result. The problems associated with either free, combined, or reaction gases in metals are difficult, but we may hope that in time they will reveal their secrets to a wiser generation. Whilst some of the effects of gaseous impurities on metals are known, the position will not be clear until gas-free standards have been prepared to serve as bases for comparison.

The spectograph which has served so nobly in the facile detection of solid impurities has already given promise of possibilities in the field of gaseous impurities.

As regards virgin metals, our knowledge of their true composition is incomplete. It is not possible to write down a complete analysis of a common metal such as copper. Although ultimate analysis goes a long way, it throws little light on the form in which the minor constituents, both metallic and non-metallic, are present. In attempting to get an insight into gaseous constituents by heating or melting in vacuum, the mere fact of increasing the temperature of the metal gives rise to a number of reactions, and the results obtained do not, therefore, represent the constituents as originally present in the metal.

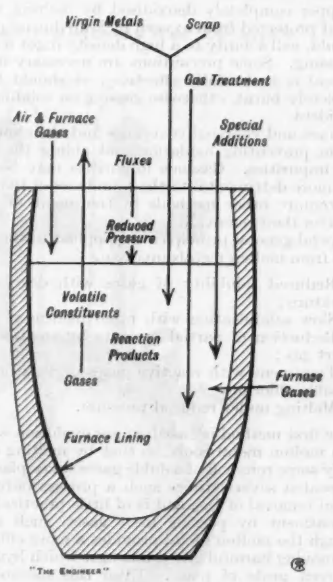
Copper 100 per cent. pure and free from gaseous constituents is not yet available, and to speak of the effect of impurities without having a pure standard as a basis for reference may be misleading, and any conclusions drawn should therefore be considered as relative rather than absolute.

When dealing with the question of impurities as affecting quality, the purpose for which the metal or alloy is required must be kept clearly in mind, and an impurity which may be harmful for certain applications may be beneficial for others. Silver in copper is a case in point. For a certain electrical application a copper free from silver is required, and in such a case a copper prepared from a silver-free ore must be used. For the majority of applications small quantities of silver are not detrimental, and there are some in which specific additions of silver are of advantage. Cuprous oxide, another common constituent in copper, whilst not harmful for many applications, may be distinctly so for others, hence the extended use of deoxidised copper and, in recent years, that of so-called oxygen-free copper. Whilst oxygen-free copper has valuable mechanical properties, complete freedom from oxygen decreases its electrical conductivity, which, however, is increased if small residual amounts of oxygen are left in the metal, and oxygen-free copper would be more truly designated low-oxygen copper.

The effect of small quantities of impurities must not be judged solely from their individual behaviour, but also from their effect on the behaviour of other impurities. It is well known that small quantities of bismuth which may be harmful in a deoxidised or oxygen-free copper become much less so in the presence of oxygen, owing to a change over from the injurious metallic state in the absence of oxygen to the less harmful oxide condition.

When reviewing the effect of impurities in virgin metals on the quality of metal produced, it is evident from the above few examples that no general statements can be made as to what impurities are likely to be harmful without first knowing what other impurities are present and the special application for which the metal is required.

Melting for quality presents many difficulties even when virgin metals are the only raw materials used; but the use of scrap, an economic necessity, still further complicates the problems involved, which are similar, but more intense, than those associated with virgin metals. In addition to any undesirable constituents which may have been present in the original virgin metals, scrap may have suffered deterioration during the melting operations through which it has passed, and, further, it may be contaminated by adherent as well as constitutional impurities. Owing to sampling and other difficulties, it is frequently impossible to assess its composition accurately, especially when in loose form, but much can be done to overcome some of these difficulties. Cleaning by washing, magnetting, hand picking, and bundling, are helpful according to the nature of the scrap. If any serious doubt exists, the surest and, in any case, the safest, procedure lies in refining so far as possible by melting and then casting into pigs, analyses of these providing the necessary safeguard as to their suitability for use.



The use of a limited percentage of scrap is sometimes stated to be beneficial to the quality of the metal melted, whilst, on the other hand, metal from remelted scrap is frequently considered inferior to that produced from virgin metals alone. Such general statements may both be correct, and their truth dependent on the raw materials involved and methods of melting employed. The melting of virgin metals may be carefully carried out and become a refining operation, in which case scrap resulting from metal so melted may be purer than the original virgin metals from which it was made, and its use even up to 100 per cent. may lead to some improvement rather than deterioration in quality. On the other hand, virgin metals carelessly melted may suffer serious contamination, and resultant scrap may deserve all the condemnation it receives, not forgetting that the evil effects of careless melting are cumulative.

The word scrap implies something inferior; this is unfortunate, in spite of it being frequently the case, for by observing greater care during handling and melting many objections raised against its use would disappear.

CONTAMINATION DURING MELTING.

The oxygen of the air and combustion products from fuels are common sources of contamination exterior to the metals being melted, and the materials of which melting vessels and stirring rods are made may also be attacked by the molten metal. No general statements can be made as to the extent to which these outside agents may react with the metal to the detriment of its quality. Whilst access of air may require vigorous exclusion in some instances, in others oxidation by air may be advisable for the removal of undesirable constituents. Copper melting provides an example where both exclusion of air and oxidation by air may be usefully applied to one and the same metal for the production of either oxygen-free copper or refined tough-pitch copper. Exclusion of air during melting is generally advisable, as it not only prevents the formation of oxides which may become admixed with and contaminate the molten metal, but losses due to oxidation are reduced, a matter of economic importance in the melting of some metals and alloys.

Furnace gases may be even more detrimental than air if allowed to contact freely with the molten metal, for, in addition to the oxidising effect of excess air, they contain water vapour and sulphur dioxide which may lead, by interaction with metal or metallic oxides, to absorption of hydrogen or sulphur. Whilst the exposed surface of the metal may be more or less protected from contact with furnace gases, diffusion through the walls of melting vessels should not be overlooked as a possible source of contamination.

As regards the molten metal picking up undesirable impurities from the walls of the container in which it is melted, the wide range of materials from which melting vessels can be made, of metals to be melted, and of temperatures involved, call for special consideration to be given to each particular case. In commercial melting operations, economy must play a part in the choice of materials to be used, and the use of refractories of high purity to prevent slight contamination of the molten metal is not usually necessary. One safeguard which may occur in practice against what might be a more serious trouble, lies in the early production of a protective slag or oxide coating on the surface of the refractory in contact with the molten metal. The building up of such a protective coating is very evident in the case of brass melting, and the fact that the first heat out of a new crucible or freshly lined furnace is more contaminated than subsequent heats is due to this cause.

Stirring rods as a possible source of contamination come in the same category as materials for crucibles or furnace linings, except that the time of contact with the molten metal is comparatively short and the chance of pick up of undesirable impurities proportionately lessened. The old-fashioned bare iron stirring rod has been responsible for many complaints of indifferent quality in high-melting point alloys, and brass, for example, that would not soften by normal annealing might easily have received an overdose of iron from the stirring rod.

The use of mild steel melting pots is convenient and without danger for some metals of relatively low melting point, but with such metals as zinc and aluminium contamination by iron is unavoidable unless the pot be internally coated by a protective refractory wash, and even with such a precaution quality may easily be sacrificed on the altar of economy.

With all these possible sources of contamination to contend with, the production of high-quality molten metal presents many difficulties. The problems involved have much in parallel with those faced by the surgeon or physician when attempting to cure human ills and diseases. The melting pot is the operating table of the metallurgist, and it is there that he has to display his skill in curing the molten metals of their inherited or acquired diseases. Copper may suffer from chronic hydrogen, bismuth, or oxide contamination; nickel from gas, sulphur, and lead poisoning; aluminium from the ill effects of a humid climate. Besides these inherited diseases carried into the melting pot, they may become further infected during the melting process. Melting need not be an entirely surgical operation, for in some cases medicinal treatment may be preferable and the ill effects of contamination countered by suitably chosen antidotes. Once contracted the diseases may prove incurable, and then, as always, prevention is better than cure. Just as the success of an operation or medical treatment depends on a correct diagnosis of the disease, the proper treatment of a metal during melting can only be carried out in the light of information provided by preliminary complete analysis and a knowledge of the special peculiarities of different metals and alloys.

In some respects the difficulties to be overcome by the metallurgist are greater than those which the surgeon or physician has to face. Diseases in molten metals more or less affect the whole mass, and there may be no visual evidence of their presence or of the success or otherwise of any operations performed. The fact that metals are opaque draws an impenetrable veil over what is happening in the melting pot. Perhaps it is well for our peace of mind that it should be so. All that we can do is to let our imaginations run riot and draw conclusions from the post-mortem examinations made on the cold frozen castings.

REMOVAL OF UNDESIRABLE CONSTITUENTS DURING MELTING.

If the metals to be melted are of known high quality, then the precautions to be taken may be limited to protection against possible external sources of infection, a charcoal or molten flux covering perhaps being all that is necessary. Much more frequently simple melting is insufficient to ensure the desired quality and definite steps must be taken to remove or lessen the ill effects of deleterious constituents by some suitable refining treatment.

Refining agents and methods are too numerous to consider individually, but the principles involved in their use may be considered conveniently under such headings as :—

Special additions or deoxidising agents,
Fluxes,
Gas treatment, and
Melting under reduced pressure or vacuum melting.

Deoxidising agents find their widest application in the melting of copper and rich copper alloys. The solubility of cuprous oxide in molten copper leads directly or indirectly to many of the troubles associated with its own melting and that of its alloys. Fortunately, there are many other metals and non-metals which have a greater affinity for oxygen than copper itself, and the addition of one of these causes the oxygen to part company with the copper and attach itself to the added element. This is, however, only an exchange of oxygen from one element to another and not necessarily a removal from the bath of molten metal, which is the desired aim. The process is akin to precipitation as carried out in chemical analysis, and if looked at in this light the complications and difficulties in the way of realising its full benefits may perhaps be more readily appreciated.

To begin with, excess of the deoxidising agent or pre-

* Fourteenth Autumn Lecture to the Institute of Metals, delivered September 9th, 1935, Newcastle-on-Tyne.

† Research manager, I.C.I. Metals, Ltd., Witton, Birmingham.

cipitant must be used, so in attempting to remove one impurity, oxygen, another constituent is introduced, and this residual deoxidant may be as objectionable (but for other reasons) as the original impurity it is desired to remove, in which case, further treatment for the removal or reduction to a minimum of the residual deoxidant may be desirable. Oxides lie in a rather vicious circle. Having got rid of the original oxide and transferred it into another, how is this latter to be removed and how do we know when it is completely removed? If insoluble and lower in density, it will tend to rise to the surface of the molten metal, but these assumptions may not always be true, or, if true, need not of necessity lead to a complete removal of the oxide. In chemical work the separation of a precipitate from a solution is by no means so rapid as might be anticipated from differences in density, and may require a long time for completion, and filtration is invariably resorted to. The metallurgist is severely handicapped as compared with the chemist when it comes to the separation of solid insoluble constituents from molten metals, and the results that he frequently obtains must be only partial instead of complete. How often is adequate time given for insolubles to rise to the surface, or how far is such separation hindered by agitation of the liquid metal? Vibration of the molten metal is stated to be helpful and such a process, known as the R.W.S. process, has been applied to the production of aluminium ingots free from admixed insolubles.

The full beneficial effects of a deoxidising process are probably never realised by the use of solid deoxidants, and it is generally a case of a greater evil being displaced by a lesser one. There is again some analogy with surgical or medicinal treatments for the relief of disease, when the attempt to cure is not infrequently followed by some ill after-effects. The possibility of filtration would lead to a great step forward in the improvement of the quality of our metals by freeing them from insoluble constituents.

This question of removing reaction products due to the addition of deoxidising agents to molten metal has probably never been given the attention it deserves. So many deoxidants are available that it is difficult to make the best choice. It is generally not difficult to find other metals or non-metals which will react with oxides in the melt, the trouble lying chiefly in the finding of a deoxidant which when used in a slight excess will have the minimum detrimental effect and form a reaction product which will separate completely from the molten metal. In the case of copper some deoxidants, such as phosphorus, give a liquid reaction product in the form of cuprous phosphate, which may not be so easily separated from the molten metal as a solid reaction product. Other deoxidants, such as lithium, for example, may have the disadvantage of reacting with the silica in refractories and lead to the contamination of the melt by silicon. A gaseous deoxidant such as carbon monoxide has many advantages over solid deoxidants, in so far as the reaction products are gaseous. Whilst referring to deoxidation by the addition of deoxidants to the molten metal in the furnace, it should be remembered that all the efforts to obtain a deoxidised metal in the furnace may be wasted if precautions are not taken to protect the metal from further oxidation during transference from the furnace to the mould, when the conditions may be very favourable to oxygen pick-up. A good clean deoxidised melt may therefore give a casting contaminated with oxide or oxide reaction gases unless special precautions against surface oxidation are taken during pouring.

Deoxidation, whilst generally beneficial, may sometimes be exactly the reverse, as in the case of copper containing small quantities of bismuth, the ill effects of which are appreciably less evident in the tough-pitch than in the deoxidised metal.

The electrical conductivity of copper is seriously reduced by even the smallest quantities of residual metallic deoxidant and deoxidised copper, in spite of its many advantages, cannot be used for applications calling for the highest electrical conductivity. Thermal conductivity suffers in a similar manner.

Special additions are not limited to the purpose of deoxidation, and in nickel and its alloys, for example, their use lies more in the direction of removing the ill effects of nickel sulphide. Small additions of manganese, silicon, magnesium, or lithium react with the nickel sulphide, forming sulphides which no longer separate at the crystal boundaries, and intercrystalline fracture on working gives place to malleability.

In the case of nickel and its alloys, residual small quantities of special additions are not so deleterious as in the case of H.C. copper, and the use of suitably chosen deoxidants or rather desulphurants is therefore everyday practice.

Whilst these special additions are frequently regarded as causing the removal of oxides or sulphides, it should be borne in mind that whilst some removal may take place, the primary benefit they confer on the metal is due to conversion of deleterious oxides or sulphides into less harmful but chemically similar compounds. Complete removal would be preferable, but, for reasons already stated, the happy day when this can be accomplished has not yet arrived.

The treatment of molten metals by deoxidants is a phase of metal melting which cannot be fully developed until a closer knowledge is obtained of the equilibrium conditions which determine the reactions between the various constituents, and this fuller knowledge would lead to a much more scientific control of the melting process than is at present possible.

If the use of solid deoxidants be viewed as a precipitation method of purification, then the use of fluxes may be regarded as an extraction method, the impurities being dissolved in a suitably chosen molten salt. In some instances a flux may be used simply as a protective layer to prevent access of air or furnace gases to the molten metal. When it is required to choose a suitable flux for the removal of an impurity, the main properties to be taken into consideration are melting point, solubility of the impurity, and reaction with the material of the melting vessel. If the melting point is too high, this can be lowered by the addition of a second salt, and suitable mixtures are thus obtained within wide limits of melting point, although retaining the desired solvent properties.

The choice of a flux for the removal of any particular impurity is determined by chemical considerations. Removal of oxides and sulphides is perhaps the chief direction in which the use of fluxes is most beneficial, hence the common use of boric acid or borax, chlorides and fluorides or mixtures of these for the removal of oxides and of basic chemicals, such as lime or soda, for the elimination of sulphides.

The cleansing of molten metals by fluxes is mainly confined to reactions at the contact surfaces of the molten metal and flux, hence the advantage of stirring metal and flux together or introducing the flux at the bottom of the melt, thus giving it an opportunity of reacting with impurities as it rises to the surface.

Whilst fluxes may generally be considered as solvents for undesirable constituents, their action may go further and cause definite changes in the composition of the melt. The removal of an undesirable constituent by means of a flux may alter equilibrium conditions and give rise to a secondary change of composition. In addition, the flux may be decomposed and give rise to decomposition products which may go into solution, react with constituents, and again bring about a change in composition.

As compared with the completeness with which the chemist can purify his products by extraction methods, the metallurgist is at a severe disadvantage. Why should we not purify our molten metals by shaking them up with solvent fluxes?

The wide use of charcoal as a covering in metal melting can conveniently be considered along with that of fluxes. It not only prevents access of air to the melt, but may also act as a very thorough reducing agent. Cuprous oxide is rapidly reduced when copper is melted under a layer of charcoal, and this fact is made use of in the production of oxygen-free copper.

As compared with the removal of cuprous oxide by deoxidants, removal by melting under charcoal has the great advantage of not leaving the copper contaminated with solid residual products from the reaction with the deoxidant. The active reducing behaviour of charcoal is probably not so much due to contact of carbon with the oxide at the surface of the melt, as to solution of carbon monoxide in the molten metal.

Copper completely deoxidised by melting under charcoal, if protected from oxygen pick-up during pouring into a mould, will solidify to a high density ingot without signs of gassing. Some precautions are necessary if the use of charcoal is to be fully effective; it should be dry and completely burnt, otherwise gassing on solidification may be evident.

Fluxes and charcoal coverings find their main application in preventing oxidation and aiding the removal of solid impurities. Gaseous impurities may be equally or even more detrimental to the soundness of the cast metal, and require other methods of treatment of the molten metal for their removal.

Several general principles are applied to the removal of gases from molten metals involving:—

Reduced solubility of gases with decrease in temperature;
Slow solidification with rapid melting;
Reduction of partial pressure by treatment with an inert gas;
Treatment with reactive gases or volatile or decomposible chlorides;
Melting under reduced pressure.

The first method is based on gas evolution which occurs when molten metal cools, so that by melting and cooling slowly some removal of soluble gases takes place, but even if repeated several times such a process only leads to a partial removal of gas, and is of little practical interest.

Treatment by passing inert gases, such as nitrogen, through the molten metal provides a more efficient means of removing harmful gases, amongst which hydrogen must be given pride of place. Even this method, although sound in principle, fails to yield entirely satisfactory results when applied to the removal of hydrogen from molten aluminium.

The removal of hydrogen from molten metals by treatment with chlorine or volatile and easily decomposible chlorides, such as those of titanium, boron, or carbon, has been successfully carried out, but such treatment does not appear to be of general application and, whilst successful in the case of aluminium and some of its alloys, is said to have little effect on the hydrogen content of other metals, such as copper and magnesium.

The melting of metals under reduced pressure for the removal of gases is frequently at the same time a refining process involving the removal or decomposition of other constituents. As regards the evolved gases, some may result from liberation of dissolved or occluded gases present in the solid metal, whilst others, generally the larger volume, arise from reactions, even between solid constituents, which only take place when the metal is heated or melted. The volume and composition of the gases obtained by heating or melting under reduced pressure cannot, therefore, be taken as indicating their quantity or even existence in the solid metal. The possible reactions, though simple in themselves, become complicated by the varied equilibrium conditions that arise throughout the wide range of temperatures and pressures involved in a vacuum melting process. When reference is made to gases in metals, it is necessary, therefore, to distinguish between those which are free and "physically" liberated on melting under reduced pressure and others which result from reactions taking place at the high temperatures and low pressures involved in a vacuum melting process.

Oxides may be decomposed and thus removed from the melt, or they may be reduced by carbon giving rise to carbonaceous gases, and reactions which are incomplete at atmospheric pressure may run much nearer to completion under reduced pressure. Whilst complete removal of gases is not obtained, their concentration may be decreased to a point at which they are no longer harmful, and definite improvement of quality results. When gases arising from reactions with oxides are the main source of trouble, their formation may be prevented by removing the oxides by the addition of a deoxidant, an alternative which may render vacuum melting unnecessary. Metal melting under reduced pressure for the removal of gas is, naturally, limited to non-volatile metals and alloys. It can be applied to the purification of volatile metals by distillation or to the removal of certain volatile impurities from non-volatile metals. Bismuth, for example, can be removed from copper, but whether this is a case of fractional distillation or whether the separation is facilitated by the presence of gases, especially hydrogen, in the copper, it is difficult to say.

Other Factors Bearing on Quality.

The advantages of a fine over a coarse crystal structure in either chill or sand castings are fully recognised, and whilst the macrostructure of the casting can to some extent be controlled by casting conditions, a similar, and in many cases more complete, grain refinement can be obtained by suitable additions to the molten metal before casting. Zinc is an excellent example of a metal which tends to solidify in the form of large crystals and in which a fine macrostructure is encouraged by small additions of such metals as magnesium and lithium. In such cases the added elements are generally of very low solubility in the melt, or they form compounds of high melting point with either the metal or some of its minor constituents. The effect is not always fully developed in the casting and may reveal itself to a more marked degree after cold working and annealing. An explanation may be based on the assumption that small nuclei of insoluble compounds are formed in the molten metal before general solidification takes place. With some aluminium alloys treatment with sodium or suitably chosen fluxes brings about a similar grain refinement in the casting. As with all additions, some definite change in properties results, and in the case of zinc, for example, it would be more correct to attribute the refinement of grain to the formation of an alloy rather than to the production of a fine grain in pure zinc.

In the melting of certain metals and alloys stress is sometimes laid on the advisability of rapid melting, or of superheating the metal to a certain temperature. Whilst such procedures may be of some advantage, their importance is dependent on other considerations and they may have no marked intrinsic values in themselves. Rapid melting in fuel-fired furnaces reduces the time during which deleterious gases may be absorbed by or react with the metal, but with other conditions of melting, such as under reduced pressure, it may be better to bring the metal to the melting point more slowly. The degree of superheat to which a molten metal should be brought can only be considered in relation to the metal and the conditions of melting, keeping in mind the effect of temperature on gas absorption, viscosity, volatility, and possible reactions.

With a clear understanding of the many factors which may influence the quality of metals and alloys due to the process of melting, it is not difficult to anticipate the relative advantages and disadvantages of the many types of melting furnaces and fuels. It is impossible to make any general statements as to the most suitable type of furnace and fuel without reference to the metal or alloy to be melted. Where products of fuel combustion are likely to be definitely detrimental, then the use of electrical energy as a source of heat offers great advantages, but this does not mean to say that if proper precautions be taken metal of high quality cannot be produced in solid or gaseous fuel-fired furnaces. It is unlikely, however, that without the aid of electrical energy as a source of heat, melting under reduced pressure, for example, would have been commercially possible. The size of the melting vessel or furnace may not be without its effect on quality, as one of the requirements of quality is uniformity, and this is more easily attained in large melting units than in small ones. The melting of large masses of metal also facilitates the control of composition by analysis. The presence of volatile constituents, such as zinc in brass, may influence the choice of a suitable form of furnace, and furnaces of the reverberatory or vacuum melting type become unsuitable. This is not the place to discuss the merits and demerits of the many types of melting furnaces, but for any metal or alloy it should not be difficult to choose one which will meet the conditions of economic melting with high uniform quality.

In the light of this short survey of some of the problems met with in the melting of metals, a mixed feeling of satisfaction and disappointment may be justified. Satisfaction at knowing the causes of some of the troubles, disappointment at not yet having arrived at a technique which overcomes them. Continuous effort in the direction of improving quality is called for and if this introduction to the subject has outlined some of the problems involved and hinted at directions in which their solution may be sought, it has served its purpose.

CATALOGUES.

IGRANIC ELECTRIC COMPANY, Ltd., Bedford.—Details of the Igranic Turica pack wrap press.

M. AND C. SWITCHGEAR, Kelvinside Works, Kirkintilloch, Glasgow.—Pamphlet on gate and switchgear.

UNITED STEEL COMPANIES, Ltd., 17, Westbourne-road, Sheffield, 10.—Data on the machining of "Silver Fox" stainless steels.

HYLAND, Ltd., Wood-street, Wakefield.—A brochure giving details of hydraulic remote engine control for motor-driven vessels.

THE MANGANSEE BRONZE AND BRASS COMPANY, Ltd., Ipswich.—A brochure dealing in some detail with "Damaxine" phosphor bronzes.

J. AND E. HALL, Ltd., Dartford, Kent.—Publication No. 769, entitled "Refrigeration," giving particulars of the firm's history, works, and products.

VICKERS ARMSTRONGS, Ltd., Elswick Works, Newcastle-on-Tyne.—A new publication illustrating the general engineering products of the Elswick Works.

HORSELEY BRIDGE AND THOMAS PIGGOTT, Ltd., Tipton, Staffs.—Catalogue of pressed steel tanks constructed from standard 4ft. or 5ft. square sections.

HACKBRIDGE ELECTRIC CONSTRUCTION COMPANY, Ltd., Walton-on-Thames, Surrey.—Publication No. DB11 on large naturally cooled transformers of over 1000 kVA.

COMPONENT FITTINGS, Ltd., 68, Victoria street, S.W.1.—Leaflet describing the Marsden rotary seal—a mechanical gland packing for all pumps, air compressors, valves, &c.

GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, W.C.2.—Catalogues on electric fans, airbreak switchgear, lightning arresters, and fractional horse-power motors.

TRANSPORT ENGINEERING AND EQUIPMENT COMPANY, Ltd., 24, York-place, Leeds.—A loose-leaf catalogue of the firm's specialities manufactured under the trade name "Kelbus."

INSTRUMENTS AND OTHER CONTROL DEVICES AT OLYMPIA

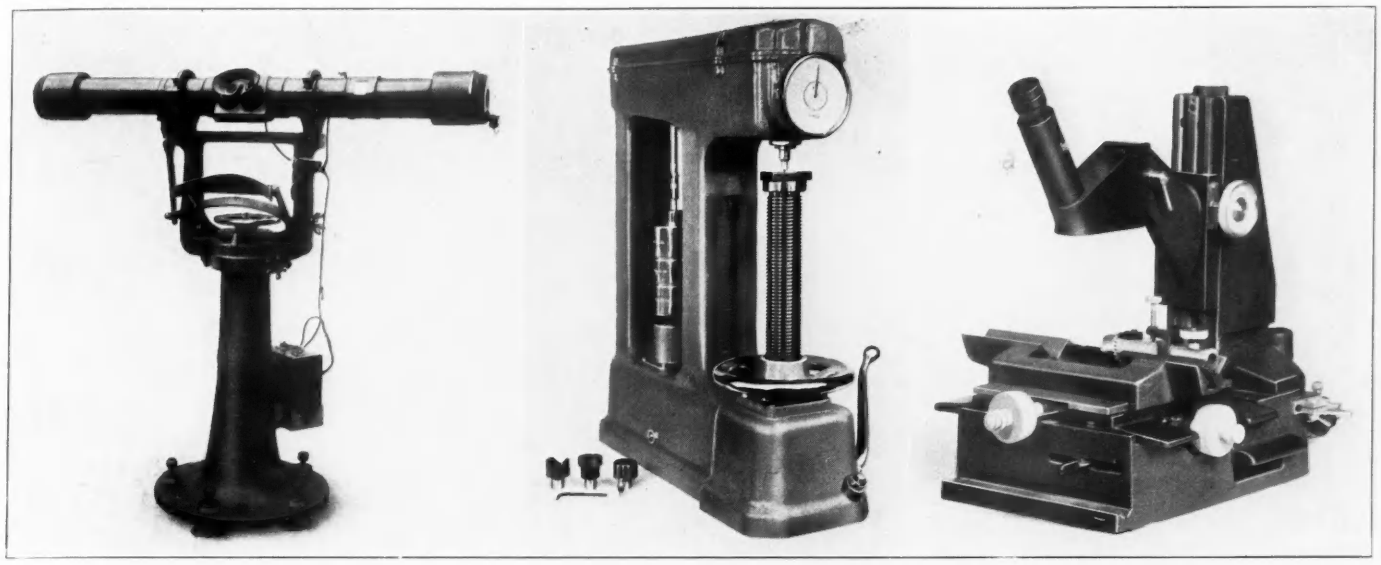


FIG. I—NAVIGATIONAL RANGE-FINDER—BARR AND STROUD

FIG. II—HARDNESS TESTER—AVERY

FIG. III—TOOLMAKERS' MICROSCOPE—LEITZ

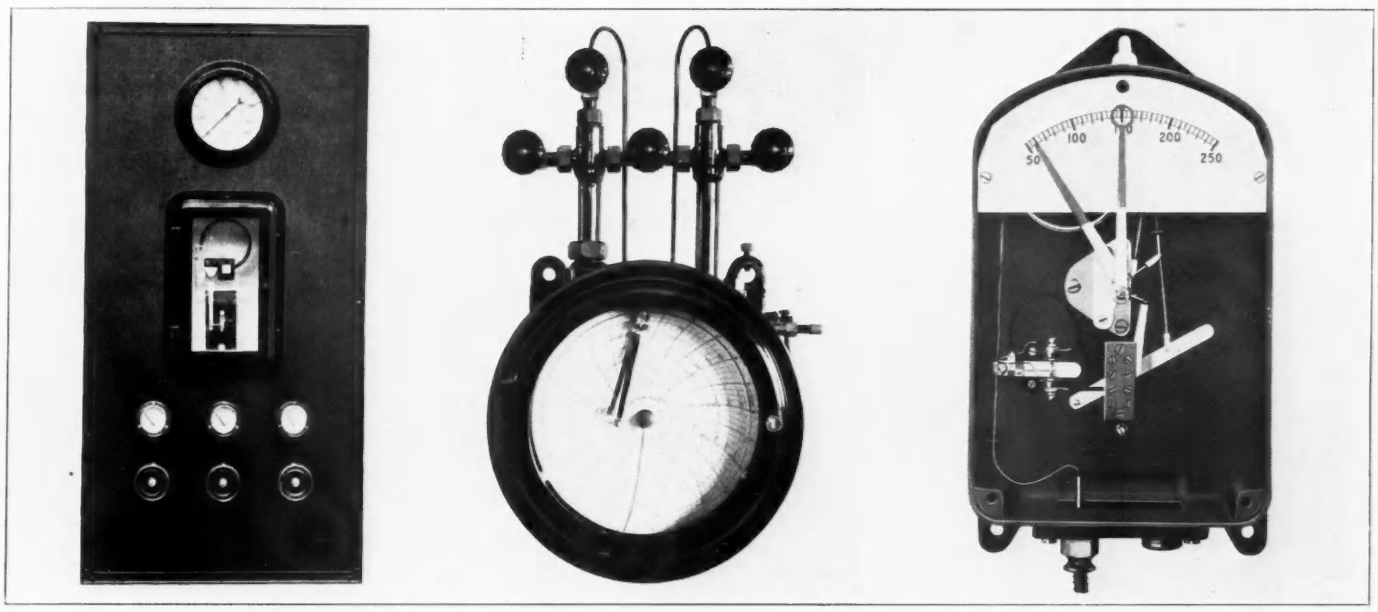


FIG. IV—BOILER CONTROL PANEL—KENT

FIG. V—FLOW RECORDER—KENT

FIG. VI—DIAL THERMOSTAT—NEGRETTI

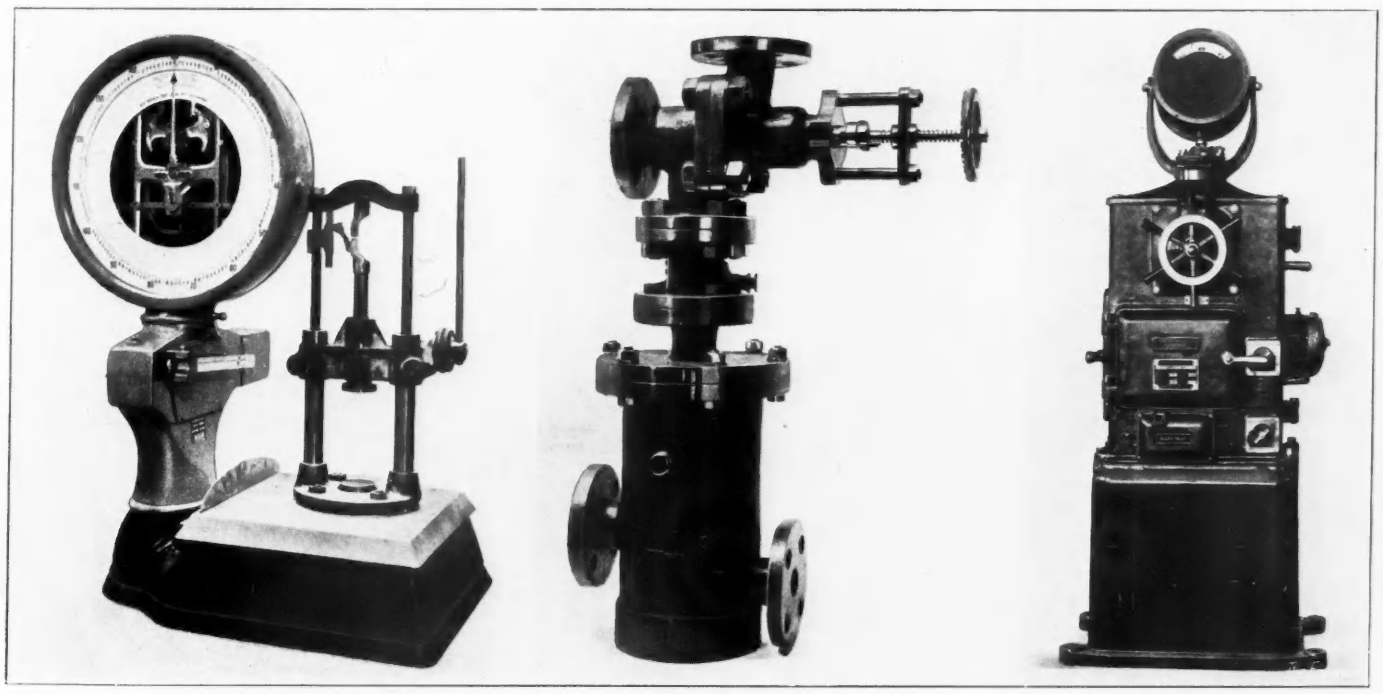
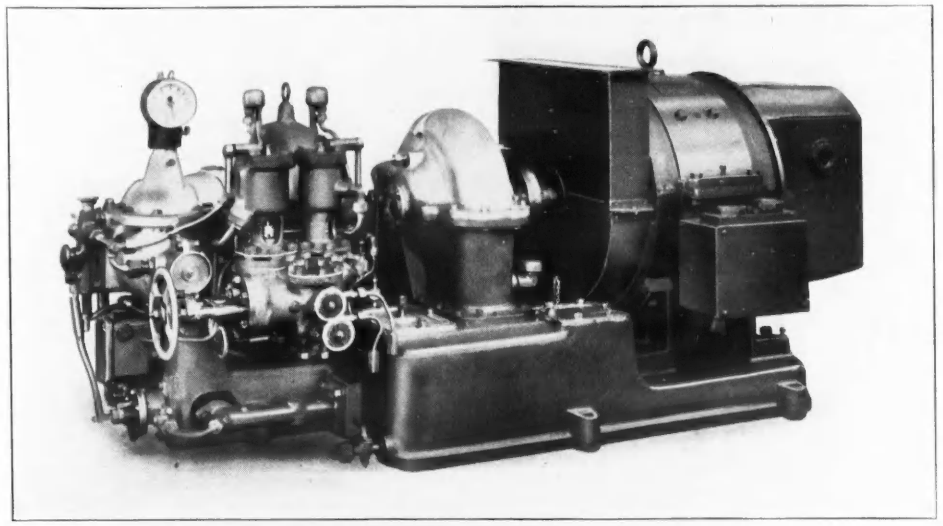
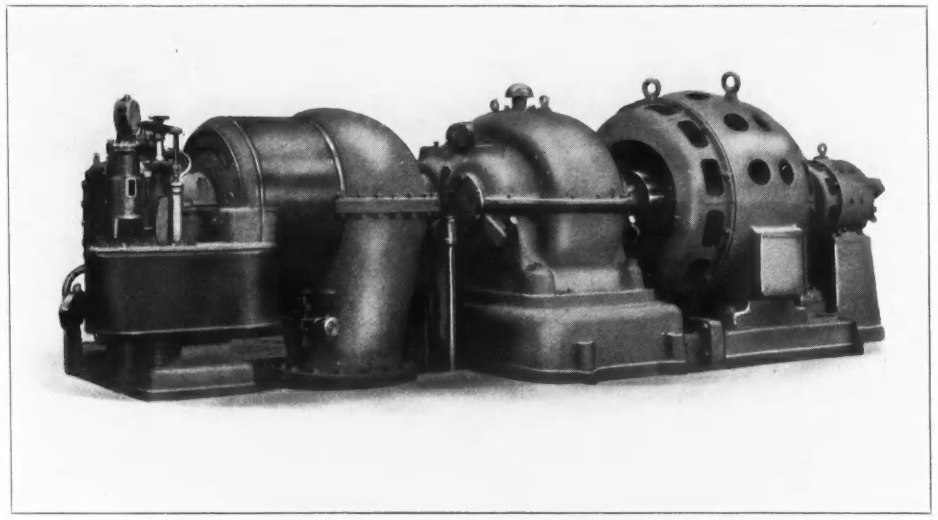


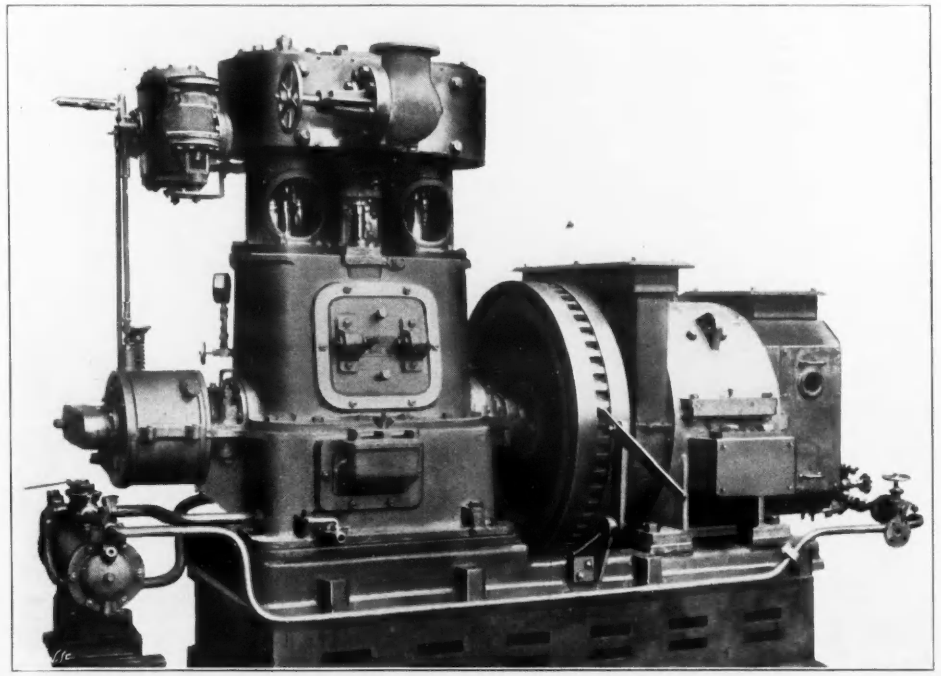
FIG. VII—SPRING-TESTING MACHINE—AVERY

FIG. VIII—MIERSBE STEAM CIRCULATOR—ALLEN

FIG. IX—AUTOMATIC HELMSMAN—BROWN







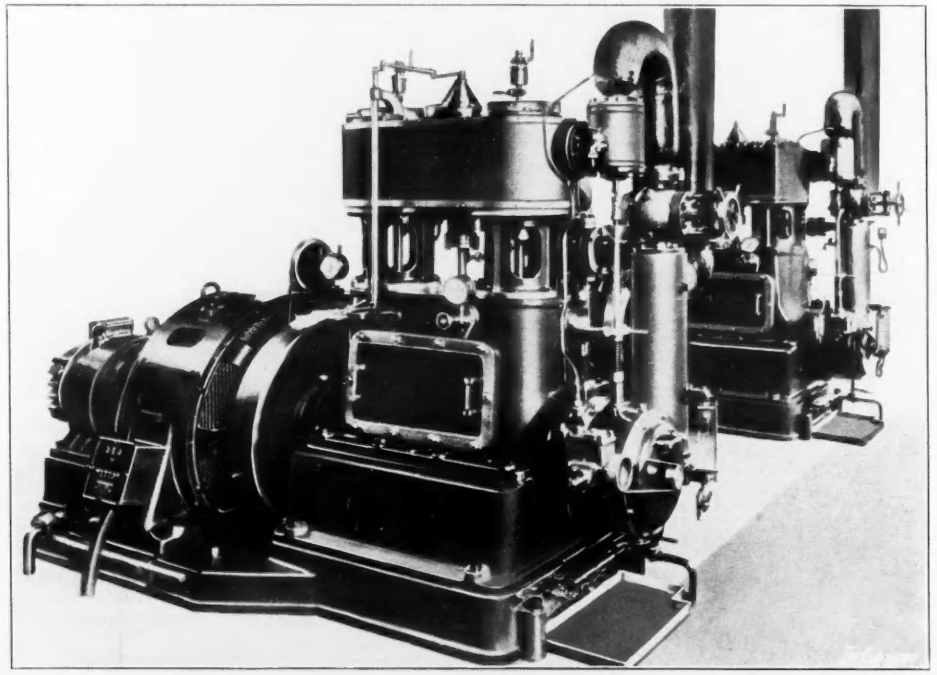


FIG. X (ABOVE)—50-KW TURBO-GENERATOR SET—ALLEN
FIG. XI (BELOW)—60-KW STEAM ENGINE AND GENERATOR—ALLEN

FIG. XII (ABOVE)—600 B.H.P. TURBO-GENERATOR—HICK, HARGREAVES
FIG. XIII (BELOW)—90 B.H.P. STEAM ENGINE SET—BROWETT-LINDLEY